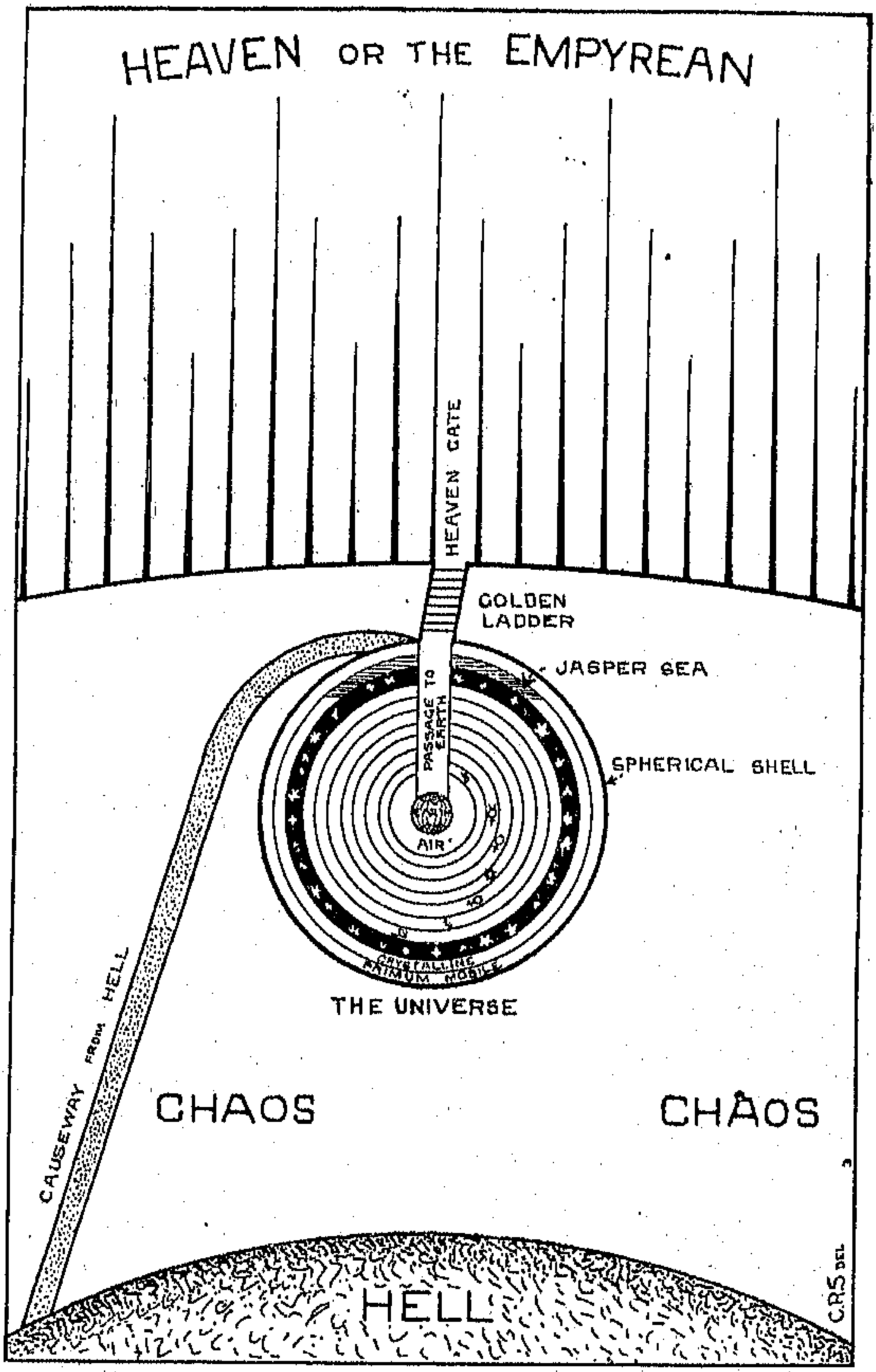
MILTON'S ASTRONOMY



SCHEME OF "PARADISE LOST"

MILTON'S ASTRONOMY

THE ASTRONOMY OF 'PARADISE LOST'

BY

THOMAS N. ORCHARD, M.D.

FELLOW OF THE ROYAL ASTRONOMICAL SOCIETY

These are thy glorious works, Parent of good,
Almighty! thine this universal frame,
Thus wondrous fair: Thyself how wondrous then!
Unspeakable.

WITH ILLUSTRATIONS

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1913

TO

THE MEMORY

OF MY DAUGHTER

MILLICENT

PREFACE

Many able and cultured writers in expatiating on the poetic genius of Milton have favoured us with elegant dissertations appreciative of the charm and sublimity of his harmonious verse. But, in discoursing on Milton's astronomy, the Author has ventured to contribute a volume, to some extent based upon an earlier work devoted to the same subject, which, whilst containing a new interpretation of certain passages in the 'Paradise Lost,' and upholding views differing from those expressed by the ablest commentators, may yet, he hopes, be interesting and instructive to the general reader. Perhaps the choicest passages in Milton's poems are associated with astronomical allusion, and it is chiefly to the exposition and illustration of these that this volume is devoted.

The Author is indebted to many writers for information and reference, and especially to Mr. C. G. Osgood, of Yale University; Mr. A. W. Verity, M.A.; Professor Walter Raleigh; Mr. E. W.

MAUNDER; and Sir ROBERT BALL. Also to the works of the late Miss A. M. CLERKE; Professors MASSON, YOUNG, and GRANT; Mr. R. A. PROCTOR; Mr. J. R. HIND; Prebendary WEBB; Rev. A. B. WHATTON; Sir DAVID BREWSTER; and Sirs W. and J. HERSCHEL. Most of the illustrations have been supplied by the Publishers. Messrs. MACMILLAN and W. HUNT & Co. have kindly permitted the reproduction of some of their drawings.

THOMAS N. ORCHARD.

PENDLETON,
MANCHESTER,
September, 1913.

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IN TEXT

Errata.

Page 11, line 20, *for* 'associated with administration of the diocese' *read* 'associated with the administration of the diocese.'

Page 31, line 26, *for* 'mean distance of the planets' *read* 'mean distances of the planets.'

Page 55, poetical quotation, line 3, *for* 'without dimensions' *read* 'without dimension.'

Page 67, line 14, *for* 'elliptic' *read* 'ecliptic.'

Page 112, line 3, *for* 'In sex thou seest' *read* 'In six thou seest.'

Page 214, line 27, *for* 'systems' *read* 'system'

Page 226, line 24, *for* 'brighter once midst the host' *read* 'brighter once amidst the host.'

Page 236, line 24, *for* 'citations' *read* 'citation.'

Page 243, *for*

'O Earth how like to Heaven, if not preferred
More justly seat worthier of gods, as built
With second thoughts,'

read

'O Earth, how like to Heaven, if not preferred
More justly, seat worthier of Gods, as built
With second thoughts,'

MILTON'S ASTRONOMY

CHAPTER I

A BRIEF HISTORICAL SKETCH OF ASTRONOMY

ASTRONOMY is the oldest and sublimest of the sciences. The dazzling splendour of the great Orb of Day; the subdued radiance of the silvery Moon with her ever-recurring phases; the lustre and glow of the swift-speeding planets; the number and brilliancy of the stars—all moving in harmonious unison and in orderly array—excite in the mind of a contemplative observer, thoughts of the deepest wonder and admiration.

When primitive man first directed his attention to the study of celestial phenomena, or at what period in the history of the human race certain observations and discoveries were made, is unknown, for no records exist that tell of the dawn of astronomy, no ray of light reveals the origin of the science, which is lost in the mists of prehistoric ages. It is, however, well known that the early inhabitants of the Earth regarded the heavenly bodies with veneration and awe, erected temples in their honour, and worshipped them as deities.

The *grouping of the stars into constellations*, having fanciful names derived from fable or ancient mythology, occurred at a very remote period. Who the people were that first mapped out these configurations on the celestial sphere is unknown, but they were true astronomers. The slender evidence which we possess on this point leads us to conclude that the Summero-Akkadians, a pastoral race that inhabited Babylonia prior to the Semitic invasion, were the first to delineate the older constellations. Traces of this ancient people exist, indicating an antiquity which dates back 4000 years before the Christian era; it is, therefore, probable that these configurations have been known to observers of the heavens for a period of at least 6000 years. By some, it has been conjectured that the necessities of early navigation gave rise to the naming of the constellations, and that it is to the sailor, and not to the shepherd and peasant, we owe the quaint imagery traced on the celestial sphere.

From very early times up to a comparatively recent period, astronomy was associated with astrology—a science that originated from a desire on the part of mankind to penetrate the future, and which was based upon the supposed influence of the heavenly bodies over human and terrestrial affairs. It was easy for primitive and untutored races, ignorant of physical laws, to imagine that the overruling power which governs and directs the course of sublunary events resides in the heavens, and that its decrees might be understood by watching the

motions of the celestial orbs under its control. It was therefore believed that by observing the configurations, or relative positions of the planets at the instant of the birth of an individual, his horoscope or destiny could be foretold, and that the occurrence of events of national importance could likewise be similarly predicted. But, after the laws which govern the motions of the heavenly bodies became better known, and especially when the discovery of the great law of gravitation revealed the true order of the universe, astrology ceased to be a belief; though, for long after, it retained its power over the imagination, and was often alluded to in the writings of poets and of other authors.

Several of the ancient peoples of the Earth aspire to the distinction of having been the earliest astronomers, and although all of them can bring weighty evidence in support of their pretensions, yet no conclusive decision can be arrived at with regard to the matter in question.

In China, astronomy has been cultivated from time immemorial, and much attention was bestowed upon it by the State on account of the importance attached to the occurrence of eclipses of the Sun. Chinese annals of astronomy claim an antiquity of 2857 years B.C., but they record little more than the appearances of comets, and the occurrence of solar eclipses. Chinese astronomers determined with great precision the obliquity of the ecliptic, and the position of the winter solstice in the heavens. They divided the year into 365¼ days, and were familiar

with the motions of the planets. For many centuries the Chinese confined their attention to observational work, which led to a few discoveries, but they made little or no progress in theoretical knowledge.

In India, astronomy is believed by some to have been cultivated from the remotest ages; an astronomical system of a very advanced character having been discovered among the Hindus. They possessed Tables of the Sun, Moon, and Planets, and calculated eclipses. It is also asserted that they ascertained the mean annual motion of Jupiter and of Saturn as early as 3062 years B.C. The high antiquity claimed for the Tirvalore Tables (3102 B.C.) is denied by certain persons who have investigated them. Some say that the epoch of the Tables corresponds with the time when Pythagoras visited India, whilst others assert that the system was introduced by the Arabs in the ninth century of our era. Notwithstanding much discussion, the matter is still involved in doubt and uncertainty.

The Egyptians studied astronomy from a very early period, but have handed down little information that is of any value. They observed eclipses of the Sun, but have not recorded them, and, on the authority of Deodorus, they predicted the appearances of comets. They were familiar with the Zodiac, and on the ceiling of a portico in the temple of Denderah a drawing of one can be seen where the crab is replaced by a scarab. Some of the pyramids are constructed so as to face the cardinal points with great exactness, and in the designing

of the Great Pyramid much astronomical knowledge is displayed. The theory ascribed to the Egyptians that the planets Mercury and Venus revolve round the Sun, is not mentioned by Ptolemy, who visited Egypt. It is believed that the Egyptians were the earliest instructors of the Greeks in astronomy.

It is now generally admitted that correct astronomical observations were first made on the plains of Chaldea. In Babylonia—a country which can boast of an antiquity rivalling that of ancient Egypt—there have been discovered the earliest trustworthy records of astronomy that we possess. These consist of a catalogue of eclipses of the Sun recorded on tablets of baked clay, the earliest of which dates from 2234 years B.C. The Chaldeans were true astronomers. They delineated the Zodiac; invented the gnomon and clepsydra, made use of several kinds of dials, and divided the day into twenty-four hours. Chaldean astronomers made accurate observations of the rising and setting of the heavenly bodies; they predicted the return of comets, and, it is said, were cognisant of the true theory of the universe.

To the Greeks belongs the credit of having first studied astronomy in a regular and systematic manner. THALES (640 B.C.) was one of the earliest of Greek astronomers, and may be regarded as the founder of the science among that people. He was born at Miletus, and afterwards repaired to Egypt for the purpose of study. On his return to Greece, he founded the Ionic school, and taught the

sphericity of the Earth, the obliquity of the ecliptic, and the true causes of eclipses of the Sun and Moon. He also directed the attention of mariners to the superiority of the Lesser Bear as a guide in the navigation of vessels, they having previously steered their course by the Great Bear. Thales believed that the Earth occupied the centre of the universe. He also predicted the occurrence of a great solar eclipse.

Thales had as his successors Anaximander, Anaximenes, and Anaxagoras, who taught the doctrines of the Ionic school.

The next astronomer and philosopher of renown that we read of is PYTHAGORAS (590 B.C.), who was born at Samos. He studied under Thales, and afterwards visited Egypt and India in order that he might make himself conversant with the scientific theories upheld by those nations. On his return to Europe, he founded his school at Crotona, in Magna Græcia, and taught in a more extended form the doctrines of the Ionic school. In his speculations regarding the structure of the universe, he propounded the theory—though the reasons by which he sustained it were fanciful—that the Sun is the centre of our system, and that the Earth and planets revolve round him. This theory—the accuracy of which has since been confirmed—received but scant attention from his successors, and it sank into oblivion until revived by Copernicus in the sixteenth century. Pythagoras discovered that the morning and evening stars are one and the same planet.

Among the famous astronomers who lived about this period we find recorded the names of Meton, who introduced the *Metonic cycle* into Greece, and erected the first sun-dial at Athens; Eudoxus, who persuaded the Greeks to adopt the year of 365¼ days; and Nicetas, who taught that the Earth completes a daily revolution on her axis.

The Alexandrian school, which flourished for three centuries prior to the Christian era, produced men of eminence, whose discoveries and observations, when arranged and classified, enabled astronomy to be regarded as a true theoretical science. The positions of the fixed stars and the paths of the planets were determined with greater accuracy, and irregularities in the motions of the Sun and of the Moon were investigated with greater precision. Attempts were made to ascertain the distance of the Earth from the Sun, and also the dimensions of the terrestrial sphere. The obliquity of the ecliptic was accurately determined, and an arc of the meridian was measured between Syene and Alexandria. The names of Aristarchus, Eratosthenes, Aristyllus, Timocharis, and Autolycus are familiarly known in association with the advancement of the astronomy of this period.

We now arrive at the name of HIPPARCHUS of Bithynia (140 B.C.), the most illustrious astronomer of antiquity, who did much to raise astronomy to the position of a true science, and who has left behind him ample evidence of his genius as a mathematician, an observer, and a theorist. He

discovered the Precession of the Equinoxes, and determined the mean motion of the Sun and of the Moon, and their irregularities of motion, with greater precision than any of his predecessors. He invented the sciences of plane and spherical trigonometry, and was the first to make use of right ascensions and declinations. We are indebted to this indefatigable astronomer for the earliest star catalogue, in which he included 1081 stars.

For more than two centuries after the death of Hipparchus we hear of no astronomer of note. The next known to fame is CLAUDIUS PTOLEMY (A.D. 130), who resided at Alexandria. He was skilled as a mathematician and geographer, and also excelled as a musician. He discovered an irregularity of the lunar motion, called the *evection*; and was the first to observe the effect of the refraction of light in causing the apparent displacement of a heavenly body. Ptolemy devoted much of his time to perfecting and extending the theories of Hipparchus, and compiled a great treatise called the 'Almagest,' which contains nearly all the knowledge we possess of ancient astronomy. His name is, however, most widely known in association with what is called the Ptolemaic theory. This system, which originated long before his time, but of which he was one of the ablest expounders, was an attempt to establish on a scientific basis the conclusions and results arrived at by early astronomers who studied and observed the motions of the heavenly bodies. Ptolemy regarded the Earth as the

immovable centre of the universe, round which the Sun, Moon, and entire heavens completed a revolution in twenty-four hours. After the death of Ptolemy, no worthy successor was found to fill his place; the study of astronomy began to decline among the Greeks, and after a time it ceased to be cultivated by that people.

The Arabs next took up the study of astronomy, which they prosecuted most assiduously for a period of four centuries. Their labours were, however, confined mainly to observational work, in which they excelled. Unlike their predecessors (the Greeks), they paid but little attention to speculative theories, which were unattractive to their minds.

The seat of astronomical learning was now transferred from Alexandria to Bagdad, where the Caliphs, good Harûn-al-Raschid and his successor Al-Mamûn, gave much encouragement to the study of the science. AL-BATANI (A.D. 880), was the most distinguished of Arab astronomers. He corrected the Greek observations, discovered the motion of the solar apogee, and was the first to make use of sines and chords. IBN-YUNIS (A.D. 1000) and ABUL WEFU were astronomers who earned a high reputation on account of the number and accuracy of their observations. In northern Persia, a descendant of the renowned warrior, Genghis Khan, erected an observatory, where new planetary tables were constructed by Nasir Eddîn, whilst Omar Khayyám, the astronomer-poet of Persia, suggested a reformation of the Calendar which, if adopted, would have insured

greater accuracy than can be attained by the Gregorian style now in use. In 1433 Ulugh Beg, grandson of the furious Tamerlane, erected an observatory at Samarcand, where he made many observations, and constructed a star catalogue which surpassed in accuracy any that existed prior to his time. The Arabs may be regarded as having been the custodians of astronomy until the time of its revival in another quarter of the globe.

Astronomy was introduced into Western Europe in the thirteenth century, and its career from that period until now has been one of triumphant progress. In 1230 a translation of Ptolemy's 'Almagest' from Arabic into Latin was accomplished by order of the German Emperor, Frederick II, and in 1252 Alphonso X, King of Castile, ordered the computation of a new set of astronomical tables, which were afterwards known as the 'Alphonsine Tables.' Purbach and Regiomontanus, two German astronomers of renown, and Waltherus, a man of distinguished reputation, made many important observations in the fifteenth century.

Pre-eminent among astronomers of the sixteenth century stands the illustrious Copernicus. Nicolas Copernicus was born February 19, 1473, at Thorn, a small town situated on the Vistula, which formed the boundary between the kingdoms of Prussia and Poland. His father was a Polish subject, and his mother of German extraction. Having lost his parents early in life, he was educated under the supervision of his uncle Lucas, Bishop of the Prussian

diocese of Ermeland. Copernicus attended a school at Thorn, and, in 1491, entered the University of Cracow, where he devoted four years to the study of science and mathematics. On leaving Cracow, he attached himself to the University of Bologna as a student of common law, and attended a course of lectures on astronomy by Novarra. In the ensuing year he was appointed canon of Frauenburg, the cathedral city of the diocese of Ermeland. In 1500 he was at Rome, where he lectured on mathematics and astronomy. He next spent a few years at Padua, where he studied medicine and obtained a degree. In 1505 Copernicus returned to his native country, and was appointed medical attendant to his uncle, the Bishop of Ermeland, with whom he resided in the stately castle of Heilsberg, distant forty-six miles from Frauenburg. During his residence at Heilsberg he pursued his astronomical studies, and undertook besides many arduous duties associated with administration of the diocese. On the death of the Bishop, which occurred in 1512, Copernicus took up his residence at Frauenburg, where he occupied his time in pondering over his new astronomy, and in undertaking various duties of a public character, which he fulfilled with credit and distinction. In 1532 he was appointed administrator-general of the diocese. Though canon of Frauenburg, Copernicus never became a priest.

After many years of profound meditation and thought, Copernicus, in a treatise entitled 'De Revolutionibus Orbium Celestium,' propounded a new

theory, or, more correctly speaking, revived the ancient Pythagorean notion of the universe. This great work, which he dedicated to Pope Paul III, was completed in 1530, but he could not be prevailed upon to have it published until 1543, the year in which he died. In 1542 Copernicus had an apoplectic seizure, which was followed by paralysis and a gradual decay of his vital and mental powers. When in this prostrate condition the earliest copy of his book, which was printed at Nuremberg, arrived at Frauenberg on May 24, 1543, in time to be touched by the hands of the dying man, who, in a few hours after, expired. The house in which Copernicus lived is still in existence, and in the walls of his chamber are visible the perforations which he made for the purpose of observing the stars cross the meridian.

To Copernicus is due the merit and distinction of having exploded the ancient Ptolemaic theory of the universe. This he accomplished by proving that *the Sun, and not the Earth, is the centre of our system.* He accounted for the alternation of day and night by the rotation of the Earth on her axis, and for the vicissitudes of the seasons by her revolution round the Sun. Copernicus perceived that the complications and entanglements introduced from time to time into the Ptolemaic system in order to explain certain irregularities of motion among the celestial orbs were strangely at variance with the simple and orderly manner in which other natural phenomena presented themselves to his observation. By perceiving that Mars, when in opposition, was not

much inferior in lustre to Jupiter, and when in conjunction resembled a star of the second magnitude, he concluded that the Earth could not be the central point round which the planet circled. Having discovered in some ancient manuscripts a theory ascribed to the Egyptians, that Mercury and Venus revolved round the Sun whilst they accompanied the orb in his revolution round the Earth, Copernicus was able by this speculation to explain the alternate appearance of these planets on each side of the Sun. The varied aspects of the superior planets when observed in different parts of their orbits also led him to conclude that the Earth was not the central body round which they accomplished their revolutions. As a combined result of his observation and reasoning, Copernicus propounded the theory that the Sun is *the centre of our system, and that the Earth and* planets revolve in orbits around him. This, which is called the Copernican System, is now regarded as, and has been proved to be, the true theory of the Solar System.

TYCHO BRAHÉ was a celebrated Danish astronomer who earned a high reputation on account of the number and accuracy of his astronomical calculations and observations. The various astronomical tables that were in use in his time contained many inaccuracies, and it became essential that they should be reconstructed upon a more correct basis. Tycho possessed the requisite skill for this kind of work. He was born December 14, 1546, at Knudstorp, near Helsingborg. His father, Otto Brahé, traced his

descent from a Swedish family of noble birth. At the age of thirteen Tycho was sent to the University of Copenhagen, where it was intended that he should prepare himself for the study of the law. But after he had been in residence about a year and a half, an event occurred which decided his future career. The prediction of a great solar eclipse that was to take place on August 21, 1560, caused much public excitement in Denmark, for in those days such phenomena were associated with the occurrence of events of national importance. Tycho anticipated the eclipse with great eagerness, and during its progress watched with intense interest all the phases of the phenomenon, which appeared exactly as they were predicted. So impressed was he with what he beheld, that he resolved to pursue the study of a science by which it was believed the course of future events could be foretold. Having completed his course of study at Copenhagen, Tycho was sent to Leipzig to learn jurisprudence, but astronomy became his favourite pursuit and absorbed all his thoughts. He spent his pocket-money in the purchase of astronomical books, which he read in secret, and, after his tutor had retired to rest, he occupied his time night after night in watching the stars and making himself familiar with their courses. He followed the planets in their direct and retrograde motions, and with the aid of a small globe and pair of compasses was able, by means of his own calculations, to detect serious discrepancies in the Alphonsine and Prutenic Tables. In order to increase his

proficiency in calculating astronomical tables, Tycho studied arithmetic and geometry, and learned mathematics without the aid of a master.

Having remained at Leipzig for three years, Tycho Brahé returned to his native country in consequence of the death of an uncle, who bequeathed him a considerable estate. In Denmark he continued the pursuit of his astronomical studies, and incurred the displeasure of his friends, who regarded astronomy as useless and unprofitable. Not caring to remain among his relations, he spent the next few years in visiting the most interesting cities of Germany, and in his travels made the acquaintance of several men distinguished for their learning and love of astronomy.

In 1571 Tycho Brahé returned to Denmark, where his fame as an astronomer had preceded him. He received a hearty welcome from his relatives and friends, and his uncle, Steno Billé, who was much interested in his nephew's scientific pursuits, assigned him a portion of his house, which was fitted up as an observatory. On the night of November 11, 1572, when returning from his laboratory—for Tycho studied alchemy as well as astronomy—he beheld to his astonishment what appeared to be a new and brilliant star in the constellation Cassiopeia, situated overhead. Distrusting his senses, he directed the attention of his companions to this wonderful object, and they all declared that never before had they observed such a star. On the following night he measured its distance from the nearest stars in the constellation, and ascertained that it was a fixed

star and beyond our system. This remarkable object remained visible for sixteen months, and when at its brightest rivalled Sirius. At first it was of a brilliant white colour, but as it diminished in size it became yellow. It next changed to red, resembling Aldebaran, afterwards it appeared like Saturn, and as it decreased in size it diminished in lustre until it became invisible. In 1573 Tycho published a work which contained his observations on the new star.

His fame as an astronomer was now so great that he was received with distinction wherever he went, and on the occasion of a visit to Hesse-Cassel he spent a pleasant week with William, Landgrave of Hesse, who was himself a skilled astronomer.

Frederick II, King of Denmark, having recognised Tycho Brahé's great merits as an astronomer, expressed a wish that he should return to his native land, and as an inducement offered him a life interest in the island of Huen, situated in the Sound, on which he undertook to erect a magnificent observatory. The King also promised to confer upon him an annual pension of 2000 dollars, and in addition to this, held out a prospect of the bestowal of future favours. Tycho, who loved his country, accepted this generous offer with gratitude, and rejoiced that an opportunity had presented itself which would enable him to pursue his favourite study in quietness and peace, feeling assured that any success which might attend his future labours would redound to the credit of his native land. Whilst the observatory was in course

of erection, Tycho Brahé occupied his time in making a collection of instruments and scientific appliances of the most splendid description with which to equip the new edifice. This handsome structure, upon which the King of Denmark expended a sum of £20,000, stood on an elevated plateau near the centre of the island of Huen, and was called 'Uranienburg' (The Citadel of the Heavens). Here Tycho resided in a kind of regal state for a period of twenty-one years, during which time he pursued his astronomical labours with untiring energy and zeal, and made vast additions to astronomical science. Every phenomenon that appeared in the heavens he examined with the greatest care, and year after year carried on a regular series of observations, in order that he might determine with greater accuracy the positions of the fixed stars, and improve the Tables of the Sun, Moon and Planets. During his long residence at Huen Tycho received visits from many distinguished persons, who were attracted to his island home by his fame, and by the magnificence of his observatory.

The island of Huen is distant three miles from the coast of Sweden, six from that of Zealand, and fourteen from Copenhagen. It has a circumference of six miles, and its surface consists mainly of an elevated table-land, in the centre of which Tycho erected his observatory; the site being now indicated by two pits and a few mounds of earth—all that remains of Uranienburg.

All went well with Tycho Brahé during the

lifetime of his noble patron, but in the year 1588 Frederick II died and was succeeded by his son, a youth eleven years of age. The Danish nobles had long been jealous of Tycho's fame and reputation, and on the death of the King an opportunity was afforded them of intriguing with the object of accomplishing his downfall. It was alleged by his opponents that his astrological practices and chemical experiments were not only useless but injurious; and his enemies at the Court prevailed upon the young sovereign—urging as their excuse the impoverished state of the treasury—to withhold the pension conferred upon him by the late King. Tycho was no longer able to maintain his establishment at Huen and, fearing that he might be deprived of the island itself, deemed it advisable to rent a house in Copenhagen, to which he removed his smaller instruments. During his residence in the capital he was subjected to annoyance and persecution. An order was issued, in the King's name, forbidding him to carry on his chemical experiments, and he, besides, endured the indignity of a personal assault. Smarting under such cruel treatment, Tycho Brahé resolved to quit his ungrateful country and seek a home in some foreign land where he would be able to pursue his studies unmolested. He accordingly removed from the island of Huen all his instruments and appliances that were of a portable nature and placed them on board a vessel, and having embarked with his family and other members of his household, this interesting craft, 'freighted with the glory of Denmark,' set sail

from Copenhagen about the end of 1597, and having crossed the Baltic in safety arrived at Rostock. Here Tycho was met by a few old friends who were waiting to receive him.

Tycho Brahé was now uncertain as to where he should find a home, when the Austrian Emperor Rudolph, having heard of his misfortunes, invited him to take up his abode in his dominions, and promised that he should be treated in a manner worthy of his reputation and fame. Tycho gladly accepted the Emperor's generous invitation, and in the spring of 1599 arrived at Prague, where he found a handsome residence prepared for his reception. He was most cordially received by the Emperor and treated with the greatest kindness. An annual pension of three thousand crowns was settled upon him for life, and he had his choice of several residences belonging to his Majesty, in which he might reside and carry on his scientific pursuits. From among them he selected the Castle of Benach, in Bohemia, which was situated on an elevated plateau, and commanded a wide view of the horizon. After a short residence at Benach, Tycho discovered that his ignorance of the language, and unfamiliarity with the customs of the people among whom he lived, caused him much inconvenience. He therefore resolved to ask permission from the Emperor to remove to Prague. His request was readily granted, and a suitable residence was provided for him in the city. Tycho was now joined by his family, who arrived from Wandesberg; and his large instruments having been

sent from Huen, he was soon comfortably settled in his new abode.

Although Tycho Brahé continued to prosecute his astronomical studies with his usual fervour and assiduity, yet he could not forget that he dwelt among a strange people, nor did the remembrance of the cruel treatment he received at the hands of his countrymen subdue the affection he cherished for his native land. Pondering over the past, he became despondent; gloomy thoughts possessed his mind, and a morbid imagination caused him to brood over fancied wrongs—symptoms which presaged the approach of some serious malady. On the evening of October 13, when visiting at the house of a friend, he was seized with a painful illness to which he succumbed in less than a fortnight. He died at Prague on October 24, 1601, aged fifty-four years.

Tycho Brahé stands out as the most prominent and romantic figure in the whole history of astronomy. His uprightness and independence of character, his ardent attachments, his strong hatreds, and his love of splendour, are characteristics which distinguish him from all other men of his age. This remarkable man was an astronomer, astrologer, and alchemist, but in his later years he renounced his belief in astrology. As a practical astronomer Tycho Brahé has not been excelled by any observer of the heavens in ancient or in modern times. He discovered the Moon's *annual equation*, a yearly effect produced by the Sun's disturbing force as the Earth approaches or recedes from him in her orbit; he

also detected another inequality of the lunar motion called the *variation*. He determined with greater precision astronomical refractions from an altitude of 45 degrees downward to the horizon; and constructed a catalogue of 777 stars. The magnificence of his observatory at Huen, upon the equipment and embellishment of which it is said he expended a ton of gold; the splendour and variety of his instruments, and his ingenious invention of new appliances would alone have made him famous; but Tycho Brahé's chief distinction as an astronomer rests upon the multitude and accuracy of his observations. They served as a basis in the computation of the Rudolphine Tables, and were of invaluable assistance to Kepler in his investigation of the laws which govern the motions of the planets.

Tycho Brahé rejected the Copernican hypothesis, but devised a system of his own which he called the 'Tychonic.' By this arrangement the Earth remained stationary, whilst the planets revolved round the Sun, who in his turn completed a diurnal revolution round the Earth. This scheme entailed the physical absurdity of causing the entire system to revolve round one of the smaller planets. It barely survived its contriver.

GALILEO GALILEI, the famous Italian astronomer and philosopher, and the contemporary of Kepler and of Milton, was born at Pisa, February 14, 1564. His father, who traced his descent from an ancient Florentine family, was desirous that his son should adopt the profession of medicine, and with this

intention entered him as a student at the University of Pisa. But Galileo soon discovered that the study of mathematics and mechanical science possessed greater attractions, and following the bent of his inclinations, he resolved to devote his energies to acquiring proficiency in those subjects. In 1583 Galileo had his attention arrested by the oscillation of a brass lamp that hung from the ceiling of the cathedral at Pisa. He was impressed with the regularity of its motion as it swung backward and forward, and conceived the idea that this movement might be of much value in the correct measurement of time, a principle which he afterwards adopted in the construction of an astronomical clock. Having become proficient in mathematics, Galileo, whilst engaged in studying the writings of Archimedes, wrote an essay on the 'Hydrostatic Balance,' and composed a treatise on 'The Centre of Gravity in Solid Bodies.' The reputation which he earned by these contributions to science procured for him the appointment of Lecturer on Mathematics in the University of Pisa. Galileo next directed his attention to the works of Aristotle, and made no attempt to conceal the disfavour with which he regarded many of the doctrines taught by the Greek philosopher. One of these, which maintained that the heavier of two bodies descends to the Earth with the greater rapidity, he proved to be incorrect, and demonstrated by experiment from the top of the tower at Pisa that, except for the unequal resistance of the air, all bodies fall to the ground with the same velocity.

As the chief expounder of the new philosophy, Galileo had to encounter the prejudices of the followers of Aristotle, whose antagonism became intensified by the bitterness and sarcasm which he imparted into his controversies; indeed, the attitude assumed by his enemies, who were both numerous and influential, became so menacing that, in 1591, he deemed it prudent to resign the Chair of Mathematics at Pisa. In the following year he was appointed Professor of Mathematics in the University of Padua, where his fame attracted crowds of pupils from all parts of Europe.

In 1613 Galileo published a work in which he declared his adherence to the Copernican hypothesis, and openly avowed his disbelief in the astronomical facts recorded in the Scriptures. He maintained that the Sacred Writings were not meant to impart scientific information, and that it was impossible for men to ignore phenomena witnessed with their eyes, or disregard conclusions arrived at by the exercise of their reasoning powers. The champions of orthodoxy having become alarmed, an appeal was made to the ecclesiastical authorities to assist in suppressing this recent astronomical heresy and other obnoxious doctrines, the authorship of which was ascribed to Galileo. In 1615 Galileo was summoned before the Inquisition to reply to the accusation of heresy. 'He was charged with maintaining the motion of the Earth and the stability of the Sun—with teaching this doctrine to his pupils—with corresponding on the subject with several

German mathematicians—and with having published it and attempted to reconcile it to Scripture in his letters to Mark Velser in 1672.' These charges having been formally investigated, it was decided that Cardinal Bellarmine should communicate with Galileo, and inform him that unless he renounced the obnoxious doctrines and promised 'neither to teach, defend, or publish them in future, he should be committed to prison.' On the day following the receipt of this injunction, Galileo appeared before the Cardinal and pledged himself that he would adhere to the pronouncement of the Inquisition. Having, as they imagined, silenced Galileo, the Inquisition resolved to condemn the entire Copernican system as heretical, and in order to effectually accomplish this, they inhibited Kepler's 'Epitome of the Copernican System,' and Copernicus' own work, 'De Revolutionibus Orbium Celestium.'

On the accession of Cardinal Barberini to the pontifical throne in 1623 under the title of Urban VIII, Galileo visited Rome in order to congratulate his old friend on his elevation to the papal chair. He was received by his Holiness with marked attention and favour, was granted several prolonged audiences, and returned home laden with valuable gifts. Notwithstanding Pope Urban's great kindness, and the leniency of the Inquisition, Galileo, having ignored his pledge, published in 1632 a book in dialogue form, in which three persons were supposed to express their scientific opinions. The first upheld the Copernican hypothesis and the more advanced

philosophical views; the second person adopted a neutral attitude, suggested doubts, and made remarks of an amusing character; whilst the third individual, called 'Simplicio,' believed in Ptolemy and Aristotle, and based his arguments upon the philosophy of the ancients. As soon as this work became publicly known, the enemies of Galileo persuaded the Pope that the third person held up to ridicule was intended as a representation of himself—an individual regardless of scientific truth, and ardently attached to the opinions associated with the writings of antiquity. Immediately after the publication of the 'Dialogue,' Galileo was summoned before the Inquisition, and, notwithstanding his feeble health and advanced age, was, after a long and tedious trial, condemned to abjure by oath on his knees his scientific beliefs.

The ceremony of Galileo's abjuration was one of exciting interest and of awful formality. Clothed in the sackcloth of a repentant criminal, the venerable sage fell upon his knees before the assembled cardinals, and laying his hand upon the Holy Evangelists, he invoked the Divine aid in abjuring and detesting, and vowing never again to teach the doctrines of the Earth's motion and of the Sun's stability. He pledged himself that he would nevermore, either in words or in writing, propagate such heresies, and swore that he would fulfil and observe the penances which had been inflicted upon him. At the conclusion of this ceremony, in which he recited his abjuration word for word, and then signed it, he was conveyed, in conformity with his sentence, to the prison of the Inquisition.[1]

After having been detained in custody for a few days, Galileo was released, and went to reside at

[1] Brewster's *Martyrs of Science*.

Siena, where he stayed for six months. Permission was afterwards given him to return to his villa at Arcetri, and although regarded as a prisoner of the Inquisition, he was allowed to pursue his studies unmolested during the remainder of his days. Galileo died at Arcetri on January 8, 1642, in the seventy-eighth year of his age.

The sarcasm and bitterness which Galileo imparted into his controversies were more the cause of his misfortunes than his advanced opinions, and although his breach of faith with the Inquisition cannot be justified, yet it is impossible not to sympathise deeply with the aged philosopher, who, in this painful episode of his life, was compelled to go through the form of making a retractation of his scientific beliefs in circumstances of a most humiliating nature.

Although not the inventor, Galileo was the first to construct a telescope and apply it to astronomical research. On directing his instrument to the heavens, he *made a number of remarkable and most interesting* discoveries, which were a source of wonder and delight to him. The celestial orbs, when observed through the 'optic tube,' presented a variety of detail hitherto undreamt of, and endless vistas of research were opened out by the visual aid which the telescope was capable of rendering.

Besides his contributions to astronomy, Galileo made many important discoveries in mechanical and physical science. He investigated the law of falling bodies in their accelerated motion towards the Earth, determined the parabolic law of projectiles, and

demonstrated that matter, even when invisible, possessed the property of weight.

We now reach the name of Kepler, one of the very greatest of astronomers, and a man of remarkable genius, who discovered the true form of the paths pursued by the Earth and planets in their journey round the Sun. It was upheld by Copernicus and by his successors that those orbs, in accomplishing their revolutions, describe circular paths, but Kepler, after many years of close observation and study, announced that the planetary orbits were not circular but of an oval or elliptical form. In his investigation of the laws that govern the motions of the planets, he formulated the famous theorems known as 'Kepler's Laws,' which will endure for all time as a proof of his sagacity and surpassing genius. Prior to the discovery of those laws, the Sun, although acknowledged to be the centre of the system, did not appear to occupy a central position as regards the motions of the planets, but Kepler, by demonstrating that the planes of the orbits of all the planets and the lines connecting their apsides passed through the Sun, was enabled to assign the orb his true position in relation to those bodies.

JOHN KEPLER was born at Weil, in the duchy of Würtemburg, December 21, 1571. In his youth he suffered much from ill-health, in consequence of which his education was sadly neglected. In 1586 he was sent to a monastic school at Maulbronn, and afterwards entered the University of Tübingen, where he distinguished himself and took a degree. Kepler devoted

his time to the study of science and mathematics, and became a convert to the doctrines taught by his tutor, Maestlin, who upheld the Copernican hypothesis.

In 1594 Kepler, on the recommendation of his masters, was appointed Professor of Astronomy at the University of Gratz, a post which he was well qualified to hold. He now directed his mental energies to the investigation of three important topics, viz. 'the number, the size, and the motion of the orbits of the planets.' He first endeavoured to ascertain if the sizes of the planetary orbits, or the difference of their sizes, bore any regular proportion to each other. In this he was unsuccessful. He then attempted to find out if the distances of the planets exhibited any regular ratio, but in this he was also disappointed. He next tried 'if those distances varied as the cosines of the quadrant, and if their motion varied as the Sun's, the sign of 90 representing the motion at the Sun, and the sign of 0° that of the fixed stars,' but failure still followed his investigations.

Kepler spent many years in these fruitless speculations before he was rewarded with the success in quest of which he laboured so long.

Having learned that Tycho Brahé had been able to determine the *eccentricity of the orbits of the* planets with greater precision than they had hitherto been known, Kepler, in order to avail himself of these observations, resolved to pay him a visit. He arrived at Prague in January 1600, and was cordially received by Tycho, who invited him to his residence

at Benach, where he stayed with him for several months. *On the termination of his visit*, Kepler returned to Gratz, but soon after resigned his professorship—the income derived from which was very small—and relying on a promise made by Tycho that he would use his influence with the Austrian Emperor to procure him a post in his observatory, he again journeyed to Prague, and arrived there in 1601. Kepler was presented by Tycho to the Emperor, who conferred upon him the title of Imperial Mathematician, and arranged that he should assist Tycho Brahé with his astronomical calculations. This appointment was of inestimable value to Kepler, *for it gave him access to the multitude of observations* made by Tycho, which were indispensable in the investigation of the subject of his choice, viz. the laws which govern the motions of the planets, and the form and size of the planetary orbits.

The two astronomers now resolved to compute a new set of astronomical tables, and in acknowledgment of the Emperor's great kindness, they decided to call them the 'Rudolphine Tables.' This project flattered the vanity of their imperial master, who promised to defray the cost of their publication. But in consequence of the departure of Longomontanus, Tycho's chief assistant, who obtained an appointment in Denmark, and the death of Tycho Brahé, which occurred in 1601, this important undertaking was suspended for a time.

Kepler succeeded Tycho Brahé as Chief Mathematician to the Emperor—a position of honour and

distinction to which was attached a handsome salary, but in consequence of expensive wars that drained the Imperial Treasury, Kepler's pay was always in arrear. This involved him in serious pecuniary embarrassment. He describes himself as 'perpetually begging his bread from the Emperor,' and was at times reduced to such straits as to be under the necessity of 'casting nativities' in order to obtain money to meet his most pressing requirements.

Notwithstanding these financial troubles, Kepler pursued his astronomical researches with much earnestness, and in 1609 published his great work entitled, 'The New Astronomy; or, Commentaries on the Motions of Mars.' The discoveries recorded in this volume form the basis of physical astronomy.

During his researches on the motions of Mars, Kepler discovered that the planet at times travelled with an accelerated speed, and that at other times its pace was diminished. At one time it would be in advance of the place where he calculated it should be found, and at another time behind it. This caused him considerable perplexity, and feeling convinced that the form of the planet's orbit was not that of a circle, he endeavoured to ascertain if any other closed curve existed by which these inequalities of motion could be explained. After many years of careful observation and profound study, Kepler discovered that the true form of the planet's orbit was that of an ellipse, and that the Sun occupied one of its foci. By examining the inequalities of

motion of the other planets, he ascertained that they all moved in elliptic orbits. This discovery is known as 'Kepler's First Law.'

Having discovered the true form of the planetary orbits, Kepler next endeavoured to ascertain the cause which regulates the unequal motion that a planet exhibits when describing its ellipse. He observed that when a planet approached the Sun its motion was accelerated, and as it receded from the orb its pace became slower. This he explained by proving that an imaginary line, or radius-vector, extending from the centre of the Sun to the centre of a planet, 'describes equal areas in equal times.' In accomplishing a definite area, a planet when approaching the Sun, or in perihelion, traverses a larger arc than when at the opposite extremity of its path or in aphelion, where a smaller arc suffices. But as the planet describes 'equal areas in equal times,' it necessarily follows that its velocity is proportionately increased or diminished as it approaches or recedes from the Sun. This discovery is known as 'Kepler's Second Law.'

By the application of his First and Second Laws, Kepler was enabled to formulate a Third Law. He found that there exists a remarkable relationship between the mean distance of the planets, and the times in which they complete their revolutions round the Sun; and discovered that 'the squares of the periodic times of the planets are to each other as the cubes of their mean distances from the Sun.' The periodic time of a planet having been ascertained,

the square of the mean distance and the mean distance itself can be readily obtained. This discovery is known as 'Kepler's Third Law.'

These remarkable discoveries are usually defined as follows :—

I. The orbit described by every planet is an ellipse, of which the centre of the Sun occupies one of the foci.

II. Every planet moves round the Sun in a plane orbit, and the radius-vector or imaginary line joining the centre of the planet and the centre of the Sun describes equal areas in equal times.

III. The squares of the periodic times of any two planets are proportional to the cubes of their mean distances from the Sun.

Kepler's delight on the discovery of his Third Law was unbounded. He writes :

> Nothing holds me. I will indulge in my sacred fury ; I will triumph over mankind by the honest confession that I have stolen the golden vases of the Egyptians to build up a tabernacle for my God far away from the confines of Egypt. If you forgive me, I rejoice ! if you are angry, I can bear it. The die is cast ; the book is written, to be read either now or by posterity—I care not which. It may well wait a century for a reader, as God has waited six thousand years for an observer.

These laws have elevated modern astronomy to the position of a true physical science ; they formed the groundwork upon which Newton based his splendid achievements, and have earned for their discoverer the proud title of 'Legislator of the Heavens.'

[2] Chambers's *Handbook of Astronomy*.

After having resided at Prague for eleven years, during which time he was sorely tried by poverty and domestic affliction, Kepler removed to Linz, having been appointed to the Chair of Mathematics in that town.

His next great undertaking was the completion of the Rudolphine Tables. They were commenced by Tycho Brahé and completed by Kepler, who made his calculations from Tycho's observations, and based them upon his own great discovery of the ellipticity of the orbits of the planets. The Rudolphine Tables were published at Ulm in 1627. Kepler made a special journey to Prague in order to present them to the Emperor; and the Grand Duke of Tuscany afterwards sent him a handsome gift as an acknowledgment of his appreciation of the completion of this great work.

On the invitation of the Duke of Friedland, who made him most liberal offers, Kepler, in 1629, took up his abode at Sagan in Silesia. But in this remote place he experienced the greatest difficulty in obtaining payment of the life-pension conferred on him by the late Emperor Rudolph, and there was a large accumulation of arrears. In a final endeavour to recover the sum due to him, Kepler travelled to Ratisbon and appealed to the Imperial Assembly, but without success. The fatigue which he endured on the journey, combined with vexation and disappointment, brought on a violent fever that was followed by a cerebral affection which terminated fatally. He died on November 15, 1630, in the

sixtieth year of his age, and was interred in St. Peter's Churchyard at Ratisbon.

Kepler was a man of indomitable energy and perseverance, and spared neither time nor trouble in the accomplishment of any object which he took in hand. In thinking over the form of the orbits of the planets, he writes: 'I brooded with the whole energy of my mind on the subject, asking why they are not other than they are, the number, the size, and the motion of the orbits.' But many fanciful ideas passed through Kepler's imaginative brain before he made the sublime discoveries that have immortalised his name. *He predicted transits of* Mercury and of Venus, made important discoveries in optics, and was the inventor of the astronomical telescope.

We now arrive at a period in the history of astronomy when, if we take a retrospective view, we shall find that the labours of Copernicus, of Tycho Brahé, of Galileo, and of Kepler have elevated the science to a position of exalted and commanding eminence. We are indebted to those great men for our knowledge of the true theory of the universe; for the multitude of astronomical observations which formed the basis of the Rudolphine Tables; for the earliest application of the telescope to astronomical research; and for the true form and size of the planetary orbits. These lofty achievements exhibit to our gaze the solar system having the Sun at its centre with his attendant family of planets and their

satellites revolving in majestic orbits around him, and presenting an impressive spectacle of order, harmony, and design.

Among astronomers of less conspicuous eminence who lived in the seventeenth century, we find recorded the name of Christian Huygens, who was born at the Hague in 1629. He studied at Leyden and Breda, and became highly distinguished as a geometrician and scientist. Huygens made important investigations relative to the figure of the Earth, and wrote a learned treatise on the cause of gravity. He also first propounded the undulatory theory of Light; and discovered Polarisation.

One of his most useful scientific achievements was the construction of a clock that should keep accurate time. Although the pendulum movement was first adopted by Galileo, he was unable to arrange the mechanism of his clock so that its motion should be continuous. After a short time the oscillation of the pendulum ceased, and a fresh impulse was required to again set it in motion; consequently Galileo's clock was of little or no use. Huygens overcame the difficulty by so arranging the mechanism of his clock that the balance, instead of being horizontal, was directed perpendicularly, and prolonged downward to form a pendulum, the oscillation of which regulated the downward motion of the weight. This invention was highly applauded; it proved to be of much service everywhere, and was of great value to astronomers.

Huygens next directed his attention to the construction of telescopes, and displayed much skill in the grinding and polishing of lenses. When engaged in observing the planet Saturn with a telescope constructed by himself, and which possessed greater magnifying power than any other instrument in existence, he made a remarkable discovery which he announced in the form of a Latin cryptogram. This, when deciphered, read as follows:—'Annulo cingitur, tenuis plano, nusquam cohaerente ad eclipticam inclinatio.' 'The planet is surrounded by a slender flat ring, everywhere distinct from its surface, and inclined to the ecliptic.' Huygens perceived the shadow of the ring thrown on the planet, and was able to explain in a satisfactory manner all the phenomena associated with its variable appearance. The true form of the ring is circular, but by us it is seen foreshortened; consequently, when the Earth is above or below its plane, it appears of an elliptical shape. When the position of the planet is such that the plane of the ring passes through the Sun, the edge of the ring only is illumined, and then it becomes invisible for a short period. In the same manner, when the plane of the ring passes through the Earth, the illumined edge of the ring is not of sufficient magnitude to appear visible, but as the enlightened side of the plane becomes more inclined towards the Earth, the ring again comes into view. When the plane of the ring passes between the Earth and the Sun, the unillumined side of the ring is turned towards the Earth, and during the

time it remains in this position it is invisible. Huygens discovered the Great Nebula in Orion, and Saturn's sixth satellite (Titan).

JOHANN HEVELIUS, a celebrated Prussian astronomer, was born at Dantzig in 1611. He was a man of wealth, and erected an observatory at his residence, where, for a period of forty years, he diligently carried on a series of astronomical observations. He constructed a chart of the stars, and in order to complete the work, delineated nine new constellations in spaces on the celestial vault which had hitherto been unnamed. These constellations are called Camelopardus, Canes Venatici, Coma Berenices, Lacerta, Leo Minor, Lynx Monoceros, Sextans, and Vulpecula. He also executed a chart of the Moon's surface, wrote a description of the lunar markings, and discovered the libration of the Moon in longitude.

On May 30, 1611, Hevelius observed a transit of Mercury, and published a description of the phenomenon. In his work he included a treatise by a young English astronomer named Horrox on the first recorded transit of Venus. Hevelius received Horrox's manuscript from Huygens, and in acknowledging it he writes :

> How greatly does my Mercury exult in the joyous prospect that he may shortly fold within his arms Horrox's long-looked-for and beloved Venus! He renders you unfeigned thanks that by your permission, this much desired union is about to be celebrated, and that the writer is able, with your concurrence, to introduce them both together to the public.

Hevelius made numerous researches on comets,

and suggested that the form of their paths might be a parabola.

The Cassini family affords an instance of the hereditary descent of talent transmitted from father to son through several generations.

GIOVANNI DOMENICO CASSINI was born at Perinaldo, near Nice, in 1625. He was a man of high scientific attainments, and in 1671 became Director of the Paris Observatory. He devoted a long life to trying and difficult observations, which in his later years deprived him of his eyesight. Cassini proved beyond doubt that Jupiter rotates on his axis, and assigned with considerable accuracy his period of rotation. He published tables of the planet's satellites, and determined their motions by observation of their eclipses. He also ascertained the rotation periods of Venus and of Mars; and observed an occultation of Jupiter by the Moon. Cassini discovered the dual nature of Saturn's ring, having perceived that instead of one there are two rings, separated by a dark interval. He also discovered four of the planet's satellites. Cassini made a near approach to the Solar parallax by means of researches on the parallax of Mars. He discovered the belts of Jupiter, was the first to recognise the zodiacal light, and established the coincidence of the nodes of the lunar equator and orbit.

JAQUES CASSINI, son of Giovanni, was born at Paris in 1677. He followed in his father's footsteps, and wrote several important treatises on astronomical

subjects. He investigated the period of rotation of the planet Venus, and upheld the results arrived at by his father, which were afterwards confirmed by Schroeter. Cassini made some valuable researches on the proper motion of the stars, and demonstrated that their change of position was real, and not due to a displacement of the ecliptic. He attempted to ascertain the apparent diameter of Sirus, and made observations on the visibility of the stars. Other members of this distinguished family have left behind them enduring evidence of meritorious and painstaking work, which was of much value in advancing the science of astronomy.

OLAUS ROEMER, *an eminent* Danish *astronomer*, was born at Copenhagen in 1644. He studied mathematics and astronomy under Erasmus Bartolinus, and afterwards, on the invitation of Picard, a French astronomer, who recognised the young man's abilities, took up his residence in Paris, where he continued to prosecute his astronomical studies. In 1675 Roemer, in a paper communicated to the French Academy of Sciences, announced his discovery of the progressive transmission of light. It was generally believed that light travelled instantaneously, but Roemer was able to prove the inaccuracy of this conclusion, and demonstrated that light travels in space with a measurable velocity. By diligently observing the eclipses of Jupiter's satellites, Roemer perceived that sometimes they occurred before, and sometimes after, their predicted times. This irregularity, he discovered, depended upon the position

of the Earth with regard to Jupiter. When the Earth, in traversing her orbit, moved round to the opposite side of the Sun, thereby bringing Jupiter into conjunction—his most distant point from the Earth—an eclipse occurred sixteen minutes twenty-six seconds later than it did when Jupiter was in opposition or nearest to our globe. After a long series of careful observations, Roemer concluded that this discrepancy was due to the fact that light travels with a measurable velocity, and that in traversing the additional distance—the diameter of the Earth's orbit—an interval of upwards of sixteen minutes elapsed—the time required by light to cross this portion of space. This important discovery enabled the velocity of light to be ascertained, which, according to recent estimates, is about 186,000 miles a second.

In 1681 Roemer returned to Denmark and was appointed Professor of Mathematics in the University of Copenhagen. He was also entrusted with the care of the City Observatory—a duty which his skill as an astronomer eminently qualified him to undertake. The transit instrument—a mechanism of much importance to astronomers—was invented by Roemer. It consists of a telescope fixed to a horizontal axis and adjusted so as to revolve in the plane of the meridian. The meridian circle, and altitude, and azimuth circles, also owe their existence to the inventive skill of this distinguished astronomer. Roemer resided for many years at the observatory, and continued his astronomical labours until his death, which occurred in 1710. He meritoriously attempted to determine

the parallax of the fixed stars, and it is said that the astronomical calculations and observations which he left behind him equalled in number those made by Tycho Brahé, nearly all of which perished in a great conflagration that destroyed the observatory and a large portion of the city of Copenhagen. Among other astronomers of note who lived in the seventeenth century we find recorded the names of Descartes and Gassendi, whose mathematical researches in their application to astronomy were of much value; Fabricius, Torricelli, and Maraldi, who, by their investigations and observations, added many facts to the general knowledge of the science; and Bayer, to whom belongs the distinction of having constructed the first star atlas.

In England the study of astronomy had not received the public recognition bestowed upon it on the Continent, but it had its votaries, and chief among them was a young clergyman of the name of Horrox.

JEREMIAH HORROX was born at Toxteth, near Liverpool, in 1619. Little is known of his family. His parents, it is said, occupied a humble position in life, but as they were able to give their son a classical education which qualified him for one of the learned professions, it is probable they were not so obscure as they have been represented.

Horrox received his early education at Toxteth. He afterwards proceeded to Cambridge, and was entered as a student of Emmanuel College on May 18, 1632. Having remained at the university for three

years, he returned to his native county and was appointed curate of Hoole, a desolate, low-lying tract of country, distant about eight miles from Preston. Yet it was here, on November 24, 1639, that he made his famous observation of the first recorded transit of Venus, a phenomenon with which his name will be for ever associated.

Horrox commenced the study of astronomy when at Cambridge. His love of the sublime, and the captivating influence exerted on his mind by contemplation of the celestial orbs, induced him to adopt astronomy as a pursuit congenial to his tastes, and capable of exercising his highest mental powers. He therefore applied himself with much earnestness to the study of mathematics, but had to rely entirely upon his own exertions, for at that time no branch of physical or mathematical science was taught at Cambridge.

In 1636 Horrox made the acquaintance of William Crabtree, a devoted astronomer who lived at Higher Broughton, a suburb of Manchester. There soon existed a close friendship between the two men, and frequent communications passed between them regarding the science which they both loved so well. Horrox devoted a considerable portion of his spare time to calculating ephemerides based upon the Lansberg Tables, but he discovered that they were inaccurate and unreliable. Crabtree, who was an unbeliever in Lansberg, urged him to discard the Flemish astronomer's works and apply his talents to the study of Tycho Brahé and of Kepler. Acting

on the advice of his friend, the youthful astronomer soon realised the value of Kepler's writings, and was charmed with the accuracy of observation and inductive reasoning displayed in the elucidation of those general laws the discovery of which constituted a new era in the history of astronomy. The Rudolphine Tables were regarded by Horrox as being much superior to those of Lansberg, but it occurred to him that they might be improved by changing some of the numbers and yet retaining the hypotheses. To this task he applied himself with much earnestness and assiduity, and after close application and laborious study, accomplished the arduous undertaking of bringing the Tables to a high state of perfection.

In his investigation of the Lunar Theory, Horrox outstripped all his predecessors; and it is distinctly affirmed by Sir Isaac Newton that he was the first to discover the true form of the Moon's orbit, which is that of an ellipse with the centre in the lower focus. He was also able to explain the causes of the various inequalities of the Moon's motion which render the exact computation of her elements so difficult. The *annual equation*, an effect produced by the increase and decrease of the Sun's disturbing force as the Earth approaches or recedes from him in her orbit, had its value first assigned by Horrox. This he calculated to be 11′ 16″, which is within 4″ of what it has since been proved to be by the most recent observations. The *evection*, a discovery made by Ptolemy, whereby the Moon's mean longitude

is increased or diminished, was explained by Horrox as depending upon the libratory motion of the apsides and the change which takes place in the eccentricity of the lunar orbit. These discoveries were made by Horrox before he reached the age of twenty years, and if his reputation had rested upon them alone, his name would have been honourably associated with those of men who have attained to the highest distinction in astronomy.

In a communication dated July 25, 1638, Horrox ascribes the motion of the Lunar apsides as due to the *disturbing force of the Sun.* This very remarkable expression, indicating the existence of a perturbative influence exercised by the bodies of the solar system upon each other, had never before been mentioned by any philosopher or astronomer, and the circumstance of its being perfectly true in this particular instance, enhances the merit of Horrox's sagacious surmise. His beautiful explanation of the inequality in the Moon's longitude was the last attempt made in the investigation of planetary motion prior to Newton's discovery of the principle of gravitation, and there can be little doubt but that the great philosopher in his exposition of the general principles of perturbation, as detailed by him in the first book of the 'Principia,' derived material assistance from Horrox's investigations. Indeed, had it not been for his untimely death, Horrox might have forestalled Newton in his discovery of the law of universal gravitation.

Horrox's detection of the *long inequality* in the

mean motion of Jupiter and of Saturn is another achievement which adds lustre to his name.

By a careful study of the Lansberg and Rudolphine Tables, Horrox concluded that a transit of Venus would occur on November 24, 1639. Kepler predicted transits of the planet in 1631 and 1761, but for some unaccountable reason he overlooked the transit of 1639. The transit of 1631 was invisible in Europe. Having assured himself of the accuracy of his calculation, Horrox wrote to Crabtree informing him of the expected event. In his letter he says :

> My reason for now writing is to advise you of a remarkable conjunction of the Sun and Venus on the 24th of November, when *there will be a transit. As such a thing has not happened* for many years past, and will not occur again in this century, I earnestly entreat you to watch attentively with your telescope, in order to observe it as well as you can. Notice particularly the diameter of Venus, which is stated by Kepler to be 7′ and by Lansberg to be 11′, but which I believe to be scarcely greater than 1′.

Having made careful preparations for observing the transit with his telescope, Horrox writes as follows :

> Although the corrected computation of Venus' motions which I had before prepared, and on the accuracy of which I implicitly relied, forbade me to expect anything before three o'clock in the afternoon of the 24th, yet, since according to the calculation of most astronomers the conjunction should take place *sooner*—by some even on the 23rd—I was unwilling to depend entirely on my own opinion, which was not sufficiently confirmed lest by too much self-confidence I might endanger the observation. Anxiously intent, therefore, on the undertaking, through the greater part of the 23rd and on the whole of the 24th I omitted no available opportunity of observing her ingress. I watched carefully on the 24th from sunrise to nine o'clock, and from a little before ten until noon, and at one in the

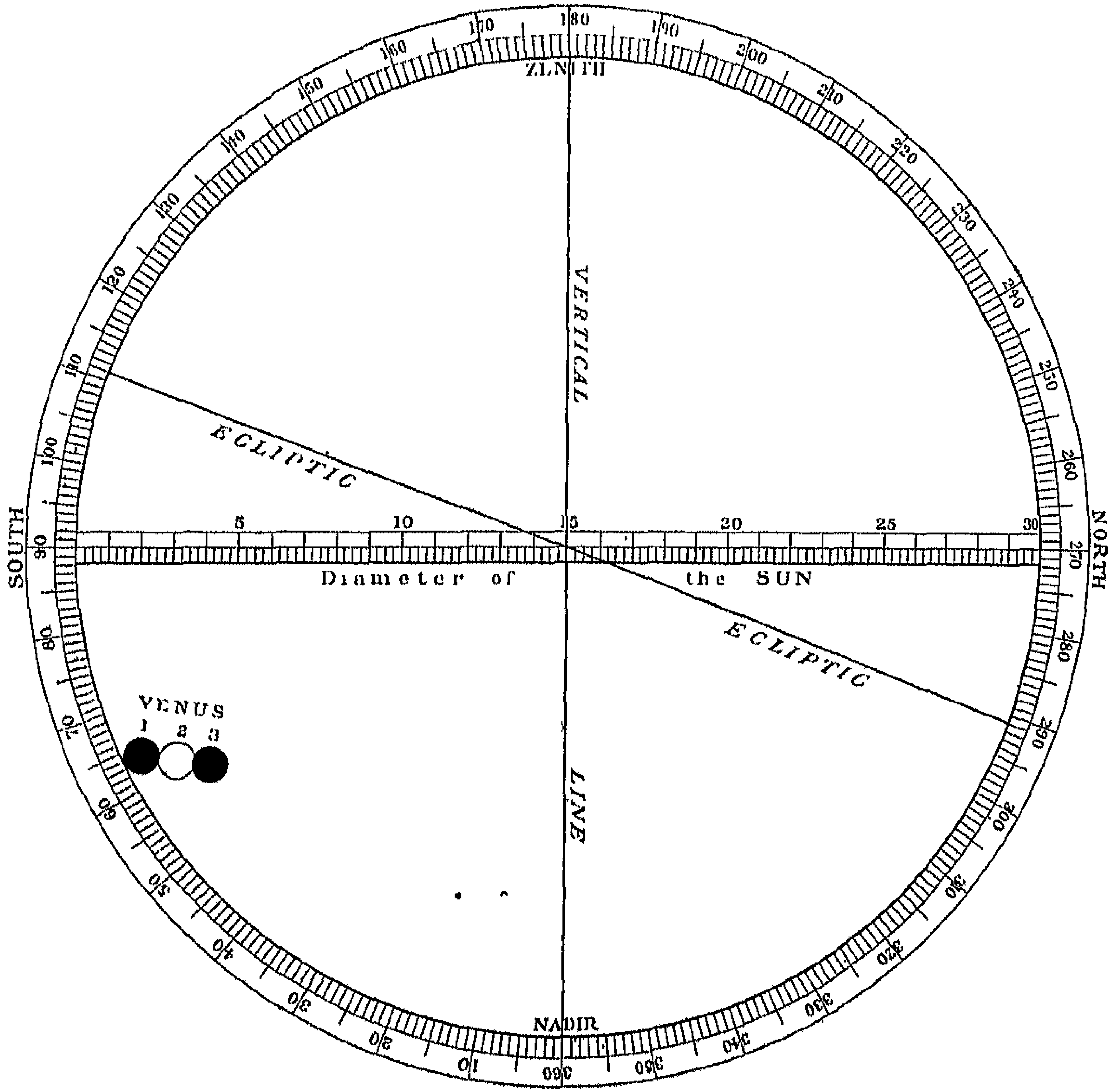
afternoon, being called away in the intervals by business[3] of the highest importance, which for these ornamental pursuits I could not with propriety neglect. But during all this time I saw nothing in the Sun except a small and common spot, consisting, as it were, of three points at a distance from the centre towards the left which I noticed on the preceding and following days. This evidently had nothing to do with Venus. About fifteen minutes past three in the afternoon when I was again at liberty to continue my labours, an opening in the clouds which rendered the Sun distinctly visible seemed as if Divine Providence encouraged my aspirations, when—Oh—most gratifying spectacle! the object of so many earnest wishes, I perceived a new spot of unusual magnitude, and of a perfectly round form that had just wholly entered upon the left limb of the Sun, so that the margins of the Sun and the spot coincided with each other, forming the angle of contact. Not doubting that this was really the shadow of the planet, I immediately applied myself sedulously to observe it.

Horrox ascertained that the diameter of Venus subtends an angle not much greater than one minute of arc. He reduced the horizontal solar parallax from fifty-seven seconds, as stated by Kepler, to fourteen seconds, a calculation within one and a half seconds of the value assigned to it by Halley sixty years after; he also reduced the Sun's semi-diameter.

Crabtree made preparations for observing the transit similar to those adopted by Horrox; but the day was unfavourable—dark clouds covered the face of the sky and concealed the Sun. Crabtree, in despair, abandoned all hope of witnessing the conjunction, when, just before sunset, there occurred a break in the clouds, and the orb shone brilliantly for a short interval. At once seizing his opportunity,

[3] The transit occurred on a Sunday, and Horrox alludes to his clerical duties.

VENUS ON THE SUN'S DISC.



Crabtree, to his intense delight, beheld the planet fully entered on the Sun's disc, but instead of proceeding to take observations, he was so overcome with emotion at the sight of the phenomenon, and continued to gaze upon it with such rapt attention, that he only regained his self-possession when the clouds again hid from his view the setting sun.[1] Crabtree's observation of the transit was, however, not a fruitless one. He drew from memory a diagram showing the exact position of Venus on the Sun's disc which corresponded in every respect with Horrox's observation; he also estimated the diameter of the planet to be $\frac{7}{200}$ that of the Sun. This, when computed, gives 1′ 3″, Horrox having reckoned it 1′ 2″.

This transit of Venus is remarkable as having been the first ever beheld with mortal eyes, and the only observers were two young men unknown to fame who resided in the north of England. We are indebted to the genius of Horrox for its prediction, the transit having occurred on the day, and almost at the very hour, when he calculated it should take place.

Having thought it desirable to write a description of the transit, Horrox prepared an elegant Latin treatise, entitled '*Venus in Sole Visa*'—*Venus seen in the Sun.*

In the meantime Horrox returned to Toxteth, and arranged to fulfil a long-promised visit to Crabtree. He anticipated with joy the prospect of meeting

[1] A fresco by the late Mr. Ford Madox Brown, depicting Crabtree observing the transit of Venus, adorns the interior of the Manchester Town Hall.

his friend, and of discussing with him matters of much interest to both. But alas! this visit was frustrated in a manner wholly unexpected, for we read that Horrox was seized with a sudden and severe illness, the nature of which is unknown, and that he died on the day prior to that of his intended arrival at Broughton. He expired on January 3, 1641, in the twenty-second year of his age.

Horrox's death was a great grief to Crabtree, and in one of his letters he alludes to it as an 'irreparable loss.' Crabtree did not long survive his friend: he died on August 1, 1644, aged thirty-four years.

Only a few of the papers written by Horrox have been preserved, and those were found in Crabtree's house after his death. All the others were irrecoverably lost. One portion of his works, which for greater security was concealed in his father's house, perished at the hands of soldiers in quest of plunder. His brother Jonas carried some of his writings into Ireland, where he died, and nothing is known of their fate. Another portion, which had been deposited in a bookseller's shop in London, was destroyed in the Great Fire of 1666. It will thus be seen how narrowly Horrox's name escaped oblivion, and how the record of all his meritorious achievements might have perished—unknown and unheard of by posterity. The remaining fragments of his works were collected and edited by Dr. Wallis Savilian, Professor of Astronomy in the University of Oxford. They were published in London in 1672

under the title of '*Jeremiae Horrocii Opera Posthuma.*' His treatise on the transit of Venus fell into the hands of Hevelius and, as has been already mentioned, was published by him along with a dissertation of his own on the transit of Mercury.

By the early death of Horrox, fair science lost a most devoted worshipper, and astronomy one of her brightest ornaments. It would seem strange that one so young should be so learned—so learned and yet so wise. Delambre says that had Horrox lived he would have proved himself the worthy successor of Kepler; and Herschel, in his praise, calls him the pride and the boast of British astronomy. No monument was erected in memory of Horrox until close on two centuries after his death, but his name, though long forgotten except by astronomers, is now engraved on marble in Westminster Abbey.

WILLIAM GASCOIGNE, 1612–1644, was born at Rothwell, in the county of York. He was of an inventive turn of mind and applied his skill to improving the methods of telescopic observation. The exact measurement of small angles was one of the difficulties with which astronomers had for long to contend. Tycho Brahé was so misled by the apparent diameters of the Sun and Moon that he concluded a total eclipse of the Sun was impossible. Gascoigne overcame this difficulty by his invention of the micrometer. This appliance, when placed in the focus of a lens, gives very accurate measurements of the diameters of the Sun, Moon, and Planets. Crabtree, in a letter to

Horrox, expresses his appreciation of the micrometer. He writes:

> The first thing Mr. Gascoigne showed me was a large telescope amplified and adorned with new inventions of his own whereby he can take the diameters of the Sun or Moon or any small angle in the heavens or upon the Earth most exactly through the glass to a second; could I procure it with travel, or purchase it with gold, I would not be without a telescope for observing small angles in the heavens.

Sherburn affirms that Gascoigne was the first to construct a telescope having two convex lenses; and Townley states that he composed a treatise on optics which was ready for publication, but that after his death the manuscript could not be found.

Having embraced the Royalist cause, William Gascoigne joined the forces of Charles I, and fell in the battle of Marston Moor on July 2, 1644. The deplorable death of this young and remarkably clever man was a severe blow to the science of astronomy in England.

The invention of logarithms by Napier; the observations of Thomas Harriot, an eminent mathematician; the investigations of Norwood and of Gilbert; the mechanical genius of Hooke, and the patient researches of Flamsteed — the first Astronomer-Royal—were of much value in perfecting many details associated with the astronomy of this period.

These pages contain a brief outline history of astronomy from the earliest times down to the death of Milton, which occurred in 1674. In the life-time of the poet, astronomy made rapid progress; many

brilliant discoveries were announced, and important controversies were finally settled. With those Milton was fully conversant, and the frequency with which he alludes to them in his poems bears ample testimony to his being well abreast of all the science and philosophy of his age.

CHAPTER II

MILTON'S COSMOLOGY

IN studying Milton's great epic, much pleasure will be missed if the student has not a clear comprehension of the poet's sublime conception of space and of the Universe; also of the relative positions of the four regions which embraced universal space, viz. HEAVEN or the EMPYREAN, CHAOS, HELL, and the MUNDANE UNIVERSE, these having formed the theatre in which the momentous events recorded in the poem are described as having occurred.

Milton derived his cosmology partly from the Mosaic record of the creation and partly from the classical mythology of ancient authors, especially Hesiod—for his spirit had drunk deeply and sympathetically of the writings of this early Greek poet. The myths and traditions which circulated among the Hellenic people, descriptive of their gods and demi-gods, and of the origin of the Universe, were first enumerated and arranged in regular sequence by Hesiod. In his 'Theogony' we find the earliest attempt to systematise the genealogy of the gods, and to describe the cosmogony or creation of

the Universe. The poet represents Chaos as primeval —'the foundation of all'—and Gaia (Earth) as first-born; from Earth sprung Cœlus (Heaven); Earth and Heaven being the progenitors of the line of the Olympian gods. Tartarus comes next into existence, whilst Chaos is answerable for the genesis of Erebus and of Night—Light and Day being the offspring of the latter. Earth in her turn brings forth the mountains and the sea. The later Orphic theogonies and cosmogonies, although more mythical and containing speculative ideas of greater refinement which tended to invest the powers of Nature with the attributes of Deity, were founded upon the theogony first described by Hesiod. To the ancient Greek, Heaven, the abode of the gods, was in the sky above, which rested upon the surface of the flat Earth. Underneath the Earth were Erebus and Tartarus, dark cavernous regions inhabited by the souls of the departed, into the latter of which the rebellious Titans were hurled by Zeus (Jupiter), after their overthrow. Around and below there raged the disorder of primeval Chaos. But Milton's Heaven was above the sky, and beyond the stars—beyond the Milky Way, and from its floor the poet suspended the Universe as a lamp in the great temple of space. Underneath the pendent World[1] he spread out Chaos, and instead of having confined the outcast angels in a prison-house below the Earth, he relegated them to a profound abyss in the uttermost

[1] The '*World*' signifies the *Universe*. Milton frequently makes use of the word in this sense.

depths of Chaos an infernal world where the rebellious were doomed to endure the punishment consequent upon their disobedience and fall.

In order to understand the cosmological scheme which Milton adopted for the requirements of his poem, it will be necessary to imagine uncircumscribed infinitude as consisting of two hemispheres, an upper and a lower. The upper hemisphere, called HEAVEN or the EMPYREAN, embraced a vast and boundless region of immeasurable extent—the lofty habitation of the Deity: a place radiant with the effulgence of His glory, and filled by His immediate and visible presence. Throughout this blissful region of light, and participating in its joys, dwells a multitude of beings called 'Angels,' or 'Sons of God,' who were created by Him. They behold the Divine Presence, hear the Divine voice, fulfil God's high behests, and execute the mandates of His sovereign will. Adoring, they draw near to His throne in worship, and with *angelic harmonies praise and extol their Creator.*

In his description of the celestial regions, Milton is careful to make use of terrestrial analogies, else he would be unable to describe what otherwise would be inconceivable. The poet portrays Heaven as a plain—

> Extended wide
> In circuit undetermined square or round.
>
> ii. 1047-48.

diversified with hills and valleys, rocks, waters, woods and caves. Its gates are of gold, embellished with sparkling gems; its walls of crystal, adorned with

battlements of living sapphire, and towers of opal; through its midst there flows the River of Bliss, and in its centre, surrounded by golden lamps, stands the Mount of God where dwells the Most High throned in brightness insufferable. Throughout its blissful regions the angelic throng, dispersed in bands and files, quaff immortality and joy by living waters, and fresh fountains shaded by trees of life. The Empyreal splendour of morn, and the subdued hues of evening, are pleasing vicissitudes of Heaven's eternal day, for night comes not there except as twilight upon Earth.

The lower hemisphere, called by Milton the 'vast immeasurable abyss,' 'the wasteful and hoary deep,' 'the vast and boundless deep,' is the realm or region of CHAOS,—a dark unfathomable abyss pervaded by the elements of matter that with incessant turmoil and confusion war with each other for supremacy. Night, as consort of Chaos, reigns over this lifeless, soulless realm of darkness, and anarchy, from out the crude contents of which it was believed the Universe was formed. Milton describes Chaos as:

A dark
Illimitable ocean, without bound,
Without dimension; where length, breadth, and highth,
And time and place are lost; where eldest Night
And Chaos, ancestors of Nature, hold
Eternal anarchy, amidst the noise
Of endless wars, and by confusion stand,
For, Hot, Cold, Moist and Dry, four champions fierce,
Strive here for mastery, and to battle bring
Their embryon atoms; they around the flag

> Of each his faction, in their several clans,
> Light-armed, or heavy, sharp, smooth, swift or slow,
> Swarm populous, unnumbered as the sands
> Of Barca or Cyrene's torrid soil,
> Levied to side with warring winds, and poise
> Their lighter wings. To whom these most adhere
> He rules a moment; Chaos umpire sits,
> And by decision more embroils the fray
> By which he reigns; next him, high arbiter,
> Chance governs all.—ii. 891–910.

Milton, with much skill and originality, introduces in this passage the ancient and mythological beliefs associated with Chaos and its occupants. In describing this region as being without dimensions, without length, breadth and height, and where time and place are lost, he excites in the mind of the reader a sense of vague incomprehensibility, whilst the presence of the four elements known to the Ancients, viz. Earth, Water, Air, Fire, not as they exist individually, 'but in their pregnant causes mixed confusedly,' adds to the perplexity already created in trying to imagine the existence of anything tangible in association with this region—

> Of neither sea, nor shore, nor air, nor fire.
> ii. 912.

Milton in his representation of Chaos follows in the wake of classical tradition, and is perhaps indebted to Ovid (*Met.* i. 5–23) more than to any other author for his knowledge of this region. The ancient poet defines Chaos as a seething welter of unorganised matter, but Milton, whose delineation of Chaos is more definite and elaborate than that of any of his predecessors, likens the tumult of the elements to

that of the heat-tormented constituents of a molten planet—

> Outrageous as a sea, dark, wasteful, wild,
> Up from the bottom turned by furious winds
> And surging waves, as mountains to assault
> Heaven's highth, and with the centre mix the pole.
>
> vii. 212–15.

Hesiod makes the earliest allusion to Chaos, but it can scarcely be said that he regarded Chaos as a divinity, and after his time this region became associated with philosophic discussion rather than with mythological fable. Classical authority in support of the existence of Chaos as a distinct divinity is very slender, but Milton personifies Chaos as reigning over this region of Anarchy, with Night as co-ruler—

> When straight behold the throne
> Of Chaos, and his dark pavilion spread
> Wide on the wasteful Deep! With him enthroned
> Sat sable-vested Night, eldest of things,
> The consort of his reign; and by them stood
> Orcus and Ades, and the dreaded name
> Of Demogorgon; Rumour next and Chance,
> And Tumult and Confusion all embroiled,
> And Discord with a thousand various mouths.
>
> ii. 959–67.

Milton sometimes describes Chaos as signifying both ruler and realm:

> 'Silence ye troubled waves, and, thou Deep, peace!'
> Said then the omnific Word: 'your discord end!'
> Nor stayed; but on the wings of Cherubim
> Uplifted, in paternal glory rode
> Far into Chaos and the World unborn;
> For Chaos heard his voice.—vii. 216–21.

Again:

Disparted Chaos overbuilt exclaimed,
And with rebounding surge the bars assailed,
That scorned his indignation. x. 416–18.

Milton alludes to Chaos in the hands of the Creator as—

His dark materials to create more worlds.
ii. 916.

Nor did it escape his philosophical observation that cosmic changes might, with the lapse of ages, reduce systems of worlds to their original chaotic condition. This he surmises when he refers to Chaos as—

The womb of Nature and perhaps her grave.
ii. 911.

The speculative and possibly correct opinion entertained by many persons that there exists but one kind of matter in the Universe, and that all substances are differentiated portions of it, would appear to have suggested itself to the poet's mind when he says:

One first matter all
Endued with various forms, various degrees
Of substance, and in things that live, of life;
But more refined, more spirituous, and pure,
As nearer to Him placed, or nearer tending,
Each in their several active spheres assigned,
Till body up to spirit work, in bounds
Proportioned to each kind.—v. 472–79.

Milton portrays an ascending scale in the order of nature both as regards the animate and inanimate, and suggests the possibility of the existence of beings

with bodies formed of matter so rare and ethereal as to be capable of blending with the spiritual. In one of his prose works he expresses the opinion that 'matter is imperishable and eternal, because it is not only from God, but out of God who is eternal.' In a less enlightened age Milton would have been called a 'pantheistic materialist,' but the wonderful discoveries made in recent years regarding the nature and properties of matter—discoveries which have deepened rather than lessened the mystery associated with its existence—render any conception of its limitation impossible; and he would indeed be a bold individual who dared venture to say where the material ended and the spiritual began. We are surrounded by matter of such extreme tenuity that it is only by the perception of phenomena induced by its motion that we are conscious of its existence. Subtle forces, emanations, and vibrations other than those of light, heat, and electricity indicate the presence of matter, the nature of which is entirely beyond our ken. It is interesting to observe how much Milton's philosophy harmonises with modern scientific research. The evolution or gradual ascent from lower to higher forms of life is a doctrine which is now almost universally upheld, and to the truthfulness of which the sciences of biology and geology bear ample testimony. The poet entertains the idea that this progressive refinement of form may go on, and suggests that eventually the—

> Time may come when men
> With Angels may participate.—v. 493–494.

These happy anticipations were, however, not based upon nor sustained by any scientific knowledge, for in Milton's time the sciences associated with the evolution of life were unknown. The poet, in the exercise of his free imagination, appears to have had an intuitive perception of what has since been revealed by science, described in his own peculiar manner, and rendered attractive by his poetic fancy. Chaos plays an important part in the elaboration of Milton's cosmology, and in the 'Paradise Lost' there are numerous happy allusions to this primordial condition of matter which formed the basis of all created things:

> Sing, heavenly Muse, that on the secret top
> Of Oreb, or of Sinai, didst inspire
> That Shepherd, who first taught the chosen seed
> In the beginning how the Heavens and Earth
> Rose out of chaos.—i. 6–10.

> As yet this world was not, and Chaos wild
> Reigned where these Heavens now roll, where Earth
> Upon her centre poised.—v. 577–79. [now rests

The ancient conception of a Chaos out of which the Universe was formed, is more in harmony with the conclusions of modern science than might at first be imagined. How this idea of a Chaos originated, no one can tell! It accounts for a beginning and agrees with the Mosaic narrative which describes the Earth as 'without form and void,' and that darkness covered the face of the Deep. The belief in the evolution of the cosmos out of a chaos is one which has gained the adherence of the majority of scientific thinkers. It is now generally admitted that the solar system in the earliest stage of its existence

consisted of a vast rotating mass of chaotic nebulous matter which occupied a region in space of far greater dimensions than is embraced by the orbit of the planet Neptune, and that by its condensation and contraction, subject to certain dynamical laws, the Sun and planets were evolved.

The two regions, viz. HEAVEN or the EMPYREAN and CHAOS, embraced universal space; nor did any modification of either take place until after the occurrence of a revolt in Heaven, when one of the highest, if not the highest archangel, known afterwards as Lucifer or Satan, rebelled, and drew after him a third of the angelic host. Then ensued a fierce contest for the empire of Great Heaven. The archangel Michael, who led the loyal armies of Heaven, gave battle to the rebel Powers. For two days the conflict raged with dubious success, but on the third day it was terminated by the intervention of Divine Might. Satan, with his rebel host, was expelled from Empyrean and driven into the Deep:

> Him the Almighty Power
> Hurled headlong flaming from the ethereal sky
> With hideous ruin and combustion, down
> To bottomless perdition; there to dwell
> In adamantine chains and penal fire.—i. 44–8.

In describing the rout of the overthrown angels, the poet says:

> Nine days they fell; confounded Chaos roared,
> And felt ten-fold confusion in their fall
> Through his wild Anarchy; so huge a rout
> Encumbered him with ruin. Hell at last,
> Yawning, received them whole, and on them closed.
> vi. 871–75.

There is now an interruption to the uniformly chaotic condition of the lower hemisphere. In order to localise Hell, Milton partitioned off a portion of Chaos situated in the lowest Deep, and there constructed his Infernal World—a vast region which consisted of fiery mountains, torrid plains, and a sulphurous lake played over by lurid flames, into which four infernal rivers disgorged their baleful streams: frozen continents, glaciers, and ice-bound Alps beat with perpetual storms of whirlwind and dire hail intensified by contrast the terrors of this place of torment:

> A universe of death, which God by curse
> Created evil, for evil only good.—ii. 622–23.

The ancient classical and mythological conception of Hell proved itself a greater attraction to Milton's imagination than the beliefs associated with this region that were in vogue at a later period of the world's history. All the Early Fathers believed Hell to be in the centre of the Earth, but St. Thomas declares that no person without a special revelation can say exactly where it is. Dante locates Hell within the Earth, and describes it as a funnel or inverted cone descending in nine diminishing whorls through the hemisphere until its central point is reached. Milton's description of Hell and of its occupants as narrated in Books I and II of the 'Paradise Lost' transcends the efforts of all other writers in their portrayal of the Infernal World.

Three regions now occupy the map of Universal Infinitude, viz. HEAVEN, CHAOS, and HELL, but a

fourth is required for the completion of Milton's cosmological scheme.

Soon after the expulsion of the rebel angels, the time long spoken of in Heaven had arrived when the Divine Power should be manifested in the creation of a New Universe and a new race of beings. This great work the Father deputed to the Messiah. He, 'girt with omnipotence,' and accompanied by hosts of angels, passed through Heaven's gates in bright procession, and rode far into Chaos, which at His command ceased its uproar. Then having stayed His chariot wheels, and taken in His hand His golden compasses, one foot He centred, the other turned round through the vast quiescent Deep, and thus decreed the limits of the Universe. At His bidding the Earth's formless mass rose out of Chaos, and over the circumscribed immensity the elementary atoms of matter rolled into whorls and vortices that condensed into suns and systems of worlds—a countless multitude of shining orbs. Thus were the Heavens and the Earth created!

The creation of the Heavens and of the Earth completes the regional delineation of Milton's cosmological scheme. The four regions, viz. HEAVEN, CHAOS, HELL, and the MUNDANE UNIVERSE embrace universal space, and are each included within the compass of the narrative descriptive of the far-reaching events and incidents recorded in the poem. Indeed, the 'Paradise Lost' may be regarded as a cosmological epic which treats not only of the Universe of Man, but also of that primeval or aboriginal Universe in which

space is lost in infinitude, and where time is measured by eternity.

Heaven and Hell are beyond the purview of science; but the cosmos, or visible Universe, in which is embraced not only our infinitesimal Earth, but also the entire starry heavens—all the orbs, clusters, systems and galaxies of stars visible to the naked eye

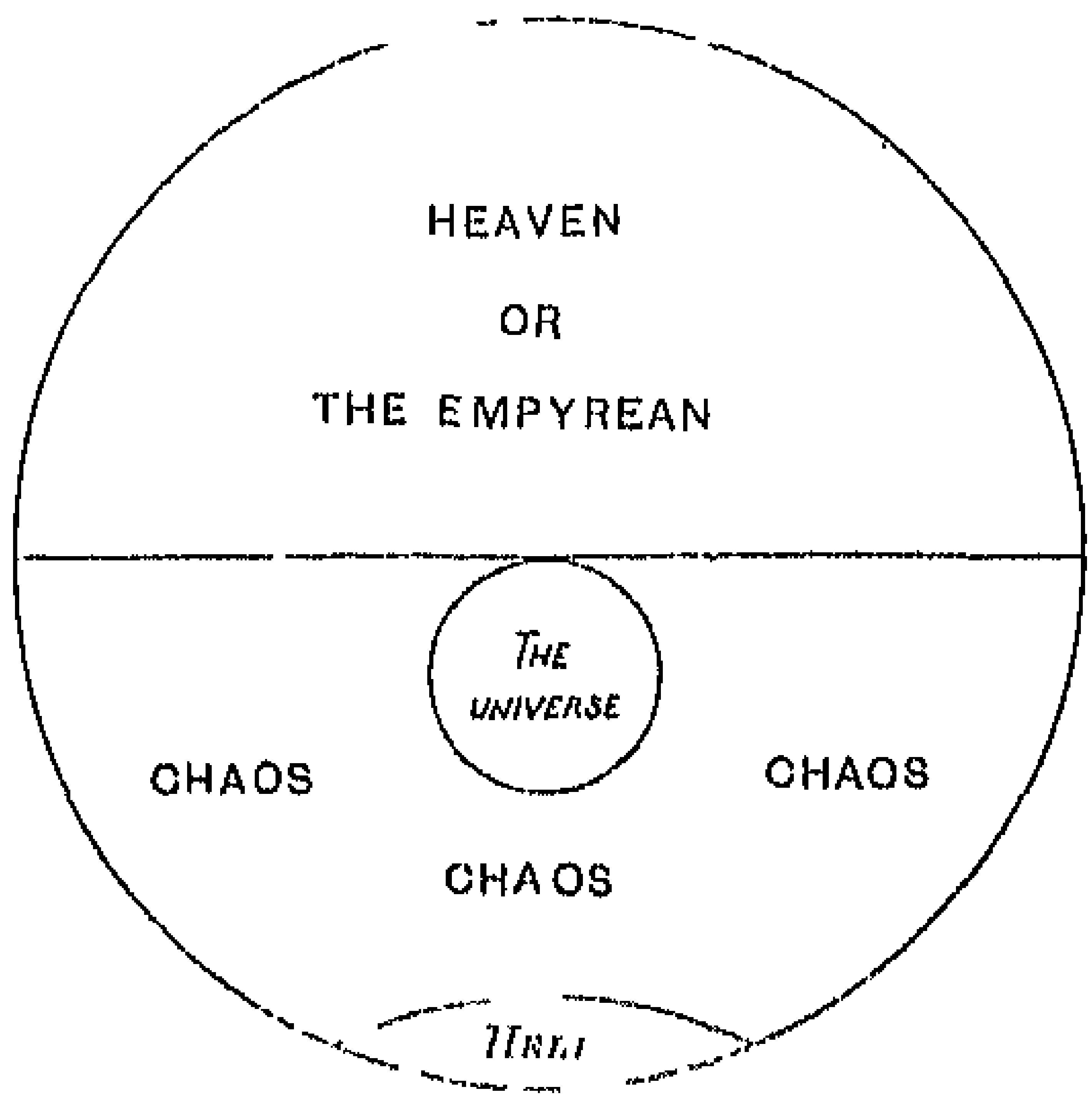


FIG. 1.—Milton's Division of Universal Space—*Masson.*

and revealed by the telescope—Milton hung pendent from the floor of the Empyrean. In order to explain its mechanism and the arrangement of the orbs which enter into its formation, it will be necessary to describe the astronomical system which the poet adopted for his 'Paradise Lost'—a system entirely different from that which is now regarded as the true theory of the Universe, and which, from the earliest times down to the beginning of the seventeenth

century was almost universally upheld by those who studied the motions of the celestial orbs. This system was known as the Ptolemaic System, having been so called after its chief expounder, Claudius Ptolemy.

According to the Ptolemaic theory the Earth was regarded as the immovable centre of the Universe. Surrounding it were certain spheres or zones of transpicuous space arranged in concentric circles, the larger spheres enclosing the smaller, and within them was situated the cosmos or Universe usually described as the Heavens and the Earth. To each of the inner seven spheres was attached a heavenly body that was carried round the Earth by the revolution of the crystalline.

1st sphere : that of the Moon.
2nd sphere : that of the planet Mercury.
3rd sphere : that of the planet Venus.
4th sphere : that of the Sun ; regarded as a planet.
5th sphere : that of the planet Mars.
6th sphere : that of the planet Jupiter.
7th sphere : that of the planet Saturn.
8th sphere : that of the fixed stars.

The eighth sphere was called the Firmament because it was supposed to impart steadiness to the inner spheres. This sphere was also believed to accomplish a diurnal revolution round the Earth, carrying in it all the fixed stars, and with it the seven other spheres ; and by its motion bringing about the alternation of day and night. The interior spheres had besides, separate and slower motions of

their own which accounted for the astronomical phenomena associated with the orbs attached to each; those of the Moon giving rise to months; of the Sun to the year; and of the planets to their

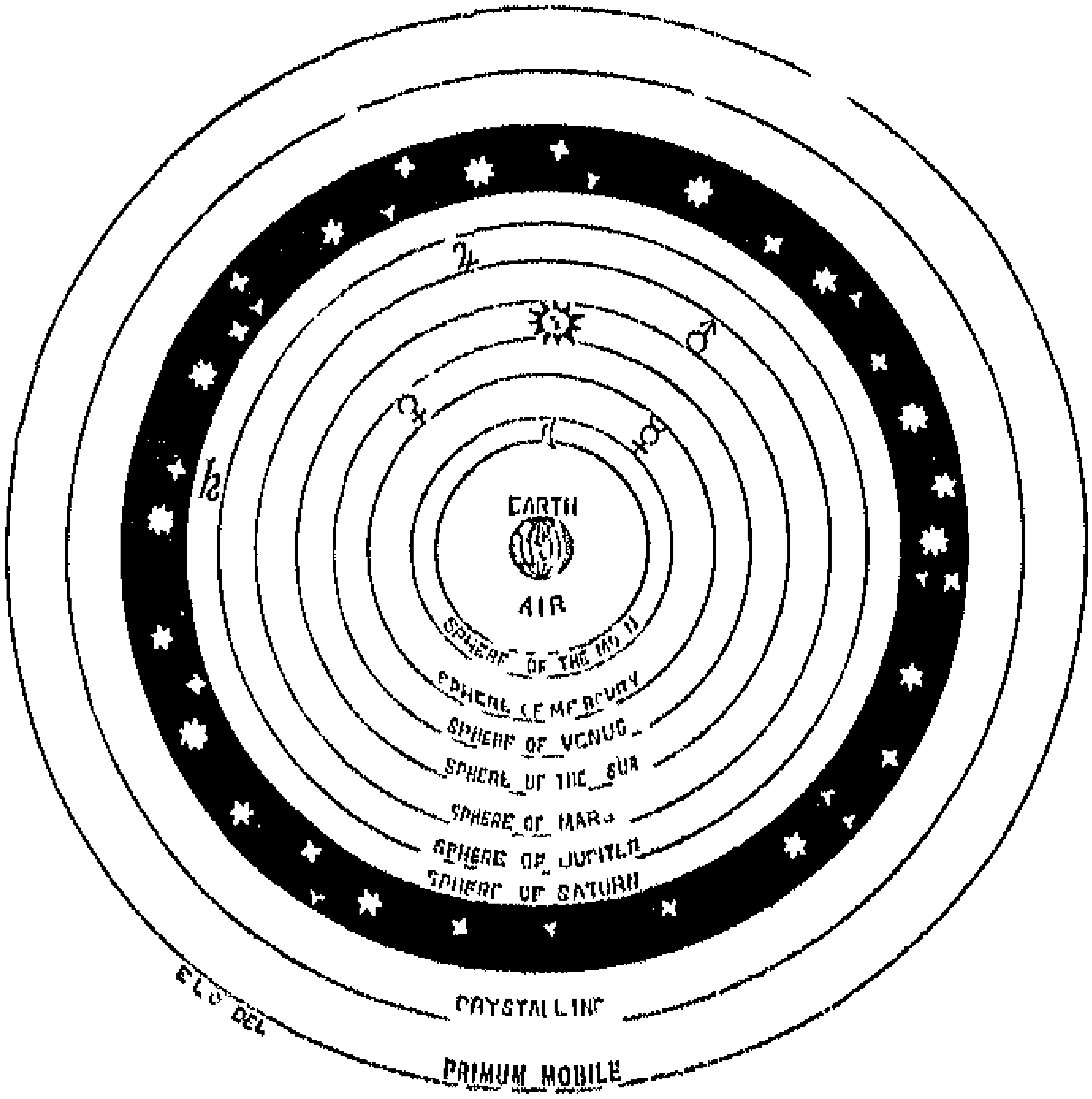


Fig. 2.—The Ptolemaic System of the Universe.

different phases. In Ptolemy's time the Universe did not extend beyond the eighth sphere, which formed its boundary. But as observations of the heavens increased in accuracy, certain irregularities of motion were perceived to occur among the celestial orbs which could not be explained by the revolution of eight spheres alone. In order to account for these, astronomers in the Middle Ages added two

other spheres to the system—a 'ninth' external to that of the fixed stars called the 'Crystalline Sphere,' which produced the slow motion known as the Precession of the Equinoxes; and a 'tenth' sphere or 'Primum Mobile' that accomplished a revolution round the Earth from east to west in twenty-four hours, causing the change of day and night by carrying with it all the other spheres. Ptolemaic astronomers were, however, unable to hazard an opinion as to how this was effected, and having been aware that the axis of motion of the Primum Mobile was that of the equator, its extremities being the poles of the heavens, whilst that of the Ninth Sphere was the axis of the elliptic, some explanation ought to have been forthcoming. This complete system of ten revolving spheres was called the Alphonsine System out of compliment to Alphonso X, King of Castile, a monarch who took a deep interest in the science of astronomy. Beyond the Tenth Sphere or 'Primum Mobile' there was believed to exist a boundless uncircumscribed region of immeasurable extent —the motionless Empyrean or Heaven of Heavens, the incorruptible abode of the Deity, a place of eternal mysteries which the mind of Man was unable to fathom, and of which he could form no possible conception.

Such were the beliefs upon which this ancient theory of the Universe was founded, that for upwards of two thousand years held undisputed sway over the minds of men, and during that period exercised a predominating influence upon the imagination,

thoughts, and ideas of all those who devoted themselves to literature, science, and art. Of the truthfulness of this assertion ample evidence may be found in the literature of our own and of other countries in which many expressions and phrases abound, descriptive of the astronomical beliefs associated with this picturesque and circumscribed conception of the cosmos. In the writings of the poets, from Chaucer down to Shakespeare, numerous ideas and sentiments, moulded in conformity with the doctrines of this ancient theory, find frequent expression in happy allusion to the 'music of the spheres.' The beliefs associated with the Ptolemaic system were gratifying to the pride and vanity of Man, who could regard with complacency the paramount importance of the globe which he inhabited, and of which he was the absolute ruler, poised in the centre of the Universe, and enclosed by ten revolving spheres that carried in their circuit all other celestial orbs - Sun, Moon and stars, which would appear to have been created for his delectation, and for the purpose of ministering to his requirements. But, when the Copernican theory became better understood, and the discovery of the law of universal gravitation revealed the true mechanism of the heavens, this venerable system of the Universe, based upon a pile of unreasonable and false hypotheses, after an existence of over twenty centuries, sank into oblivion and was heard of no more.

The ancients, in order to enhance the attractiveness of this system, associated harmonious sound

with the revolution of the spheres, hence the expression 'music of the spheres.' Cicero, in his 'Scipio Somnium'[2] describes how this harmony is produced. Scipio, in his dream, says to Africanus:

'From whence proceed these sounds so strong and yet so sweet that fill my ears?' 'The melody,' replied he, 'which you hear, and which, though composed in unequal time is nevertheless divided into regular harmony, is effected by the impulse and motion of the spheres themselves, which, by a happy temper of sharp and grave notes, produce various harmonic effects. Now it is impossible that such prodigious movements should pass in silence, and Nature teaches that the sounds which the spheres at one extremity utter must be sharp, and that those at the other extremity must be grave; on which account the highest revolution of the star-studded heaven, whose motion is more rapid, is carried on with a sharp and quick sound, whereas this of the Moon, which is situated the lowest and at the other extremity moves with the gravest sound. Now, this sound, which is effected by the rapid rotation of the whole system of Nature, is so powerful that human beings cannot comprehend it, just as you cannot look directly upon the Sun because your sight and sense are overcome by his beams.'

The harmony consisted of eight unisonious melodies, a single note emanating from each sphere; the combined notes giving rise to a diapason so 'loud, various and sweet' as not to be perceptible to human ears. Pythagoras, in his philosophy, attached much importance to the concord of numbers, and upheld the belief in the 'music of the spheres.'

The rhythmical and harmonious motion of the spheres was one of the poetic delights in which Milton's imagination luxuriated; it exerted an

[2] Milton makes two allusions to Scipio—*Paradise Lost*, IX. 105, *Paradise Regained*, III. 34.

enchanting influence upon his mind, and was one of his dearest and most captivating fancies. The happiest flights of his genius are associated with this mystical, yet unheard music, to the tune of which the Universe rolls its stately motions:

> Ring out, ye crystal spheres!
> Once bless our human ears,
> If ye have power to touch our senses so;
> And let your silver chime
> Move in melodious time,
> And let the bass of Heaven's deep organ blow;
> And with your nine-fold harmony
> Make up full consort to the angelic symphony.
>
> For if such holy song
> Enwrap our fancy long,
> Time will run back and fetch the Age of Gold;
> And speckled Vanity
> Will sicken soon and die,
> And leprous Sin will melt from earthly mould;
> And Hell itself will pass away,
> And leave her dolorous mansions to the peering day.
> H. 125-40.

In the Echo Song in 'Comus,' this music of the spheres is also introduced:

> Sweet Queen of Parley. Daughter of the Sphere!
> So may'st thou be translated to the skies,
> And give resounding grace to all Heaven's harmonies.
> C. 241-43.

In 'Arcades,' Milton links this poetic notion with the myth in Plato's 'Republic' (Book X. chapter xiv.), where the Sirens are described as seated on the revolving spheres singing in melodious concord:

> But else, in deep of night, when drowsiness
> Hath locked up mortal sense, then listen I
> To the celestial Siren's harmony,

That sit upon the nine[3] infolded spheres,
And sing to those that hold the vital shears,
And turn the adamantine spindle round,
On which the fate of gods and men is wound,
Such sweet compulsion doth in music lie,
To lull the daughters of Necessity,
And keep unsteady Nature to her law,
And the low world in measured motion draw
After the heavenly tune, which none can hear
Of human mould with gross unpurgèd ear.—A. 61–73.

This passage is founded upon Plato's description of the journey of Er after death, who, on the expiration of four days' travel, beheld a pillar of light like a rainbow but far brighter, which united the circle of the heavens. To each end of this bow of light was attached the distaff of Necessity or Fate, having a shaft of adamant, and a wheel with eight vast circles or spheres which fitted one within the other. On each circle a Muse or Siren was seated, singing in one note, the combined notes giving rise to one loud melody. Round about at equal intervals seated on thrones were the three daughters of Necessity—(the Fates)—Clotho, the spinner of life's thread; Lachesis, the assigner of destiny; and Atropos, the inexorable one, whose duty is to cut the thread of life, irrespective of age, sex, or circumstances. These accompany with their voices the harmony of the Sirens; Clotho singing of the present, Lachesis of the past, and Atropos of the future. The spindle on which the threads of human and even divine lives are wound rests on the knees of Necessity, and is turned by the

[3] In Plato's time the Ptolemaic system was represented by eight spheres. *Milton adds the ninth of the Alphonsine—a number similar* to that which Dante adopted for his poem.

three Fates who are lulled by the music of the Sirens —music so sweet and rapturous as to be unheard by mortal ears.

In his Latin Academic Prolusion, 'De Sphaerum Concentu,' Milton alludes to the harmony of the spheres, but this universal roll of music, which to the poet's imagination pervaded all nature, is perhaps most felicitously introduced in the short poem entitled 'At a Solemn Music':

Blest pair of Sirens, pledges of Heaven's joy,
Sphere-born harmonious sisters, Voice and Verse,
Wed your divine sounds, and mixed power employ,
Dead things with inbreathed sense able to pierce,
And to our high raised phantasy present
That undisturbed song of pure concent,
Aye sung before the sapphire coloured throne
To Him that sits thereon,
With saintly shout and solemn jubilee;
Where the bright Seraphim in burning row
Their loud uplifted angel trumpets blow,
And the Cherubic host in thousand quires
Touch their immortal harps of golden wires,
With those just Spirits that wear victorious palms,
Hymns devout and holy psalms
Singing everlastingly:
That we on Earth, with undiscording voice,
May rightly answer that melodious noise;
As once we did, till disproportioned sin
Jarred against nature's chime, and with harsh din
Broke the fair music that all creatures made
To their great Lord, whose love their motion swayed,
In perfect diapason, whilst they stood
In first obedience and their state of good.
O, may we soon again renew that song,
And keep in tune with Heaven, till God ere long
To His celestial consort us unite,
To live with Him, and sing in endless morn of light.

Ancient philosophers, in dealing with the distribution of matter in the Universe, assigned the central position to Earth as being the densest and most stable of the elements; next in order came Water, which was supported by Earth; above Water was Air, and beyond Air was Fire. Remoter still was the Ether, which occupied space for an indefinite distance. In describing the Ptolemaic system, it was stated that the heavenly bodies were carried round the Earth by the revolution of the spheres, each of the first seven spheres having within it one celestial orb, whilst the eighth sphere contained all the fixed stars. The ninth sphere was void of stars, but by its motion gave rise to the Precession of the Equinoxes. The tenth sphere was also destitute of stars, but in its diurnal revolution carried with it all the other spheres. It must not be imagined that the spheres consisted of any material substance; they were immense spherical shells or zones of transpicuous space, arranged one within the other, that circled round the motionless Earth with different velocities, the more distant spheres possessing the most rapid motion. In conformity with this conception of the cosmos, the dimensions of the Universe were distinctly circumscribed; it was within the power of man's mental capacity to grasp its proportions, and picture to himself its geometrical arrangement.

In his choice of the Ptolemaic as the system best adapted for the poetical requirements of the 'Paradise Lost,' Milton was evidently attracted by its picturesqueness, by its symmetrical configuration,

and by its well-defined limitation. All the authors whose works he perused and studied in his younger days, expressed their ideas in conformity with this system; his favourite poet, Dante, knew of no other, and his own poetic imaginings, as indicated in his early works, were also in harmony with the doctrines of this ancient creed, a long acquaintance with which had without doubt influenced his mind in its favour. But the Ptolemaic system did not alone suffice to provide Milton with all the requirements which he considered essential for the production of his great epic; and, strange though it may seem, the poet probably having in view the necessity of securing a firm basis upon which to rear the superstructure of his poem, enclosed the revolving spheres and their contents within a hard material shell, which with the exception of an aperture at its zenith denied all access to the glorious creation within. Milton vouchsafes to us no description of the formation of this opaque outer covering which enclosed the Universe, nor does he make any apology to his readers for the addition of this strange and improbable adjunct to the cosmos. Nevertheless, he assumes its existence, and we shall find that it served several useful purposes in the elaboration of his sublime poem.

In order to comprehend the cosmological vision which presented itself to the poet's mind, it will be necessary to accompany Satan on the adventurous journey which he undertook with the object of discovering the newly created Universe, and the

abode of Man. Standing on the brink of Hell, he plunges into the abyss of Chaos, and through the warring elements of matter pursues his long and arduous journey upward enveloped in darkness and gloom :

> But now at last the sacred influence
> Of light appears, and from the wall of Heaven
> Shoots far into the bosom of dim night
> A glimmering dawn. Here Nature first begins
> Her farthest verge, and Chaos to retire,
> As from her outmost works, a broken foe,
> With tumult less and with less hostile din;
> That Satan with less toil, and now with ease,
> Wafts on the calmer wave by dubious light,
> And like a weather-beaten vessel, holds
> Gladly the port, though shrouds and tackle torn;
> Or in the emptier waste, resembling air,
> Weighs his spread wings, at leisure to behold
> Far off the Empyreal Heaven, extended wide
> In circuit, undetermined square or round,
> With opal towers and battlements adorned
> Of living sapphire, once his native seat;
> And fast by hanging in a golden chain,
> This pendent World in bigness as a star
> Of smallest magnitude close by the Moon.
>
> ii. 1034-53.

Having emerged from the darkness of Chaos into a region of dim light, the ruined archangel beholds 'far off' his former celestial abode shining in its pristine splendour, and directly underneath 'linked in a golden chain' the New or Mundane Universe, in quest of which he journeyed hither. Its magnitude when compared with the Empyrean above is as the smallest star when seen by the edge of the full orbed Moon. Milton does not attempt to define

the figure[1] of the Empyrean, nor its dimensions, but it is difficult to perceive how, when first seen by Satan, its battlements and towers should have been visible when the great globe of the Universe, which hung underneath, should have appeared so small. The aspect of the pendent sphere in its relation to the Heaven above, although beautiful and relevant to poetic description, is not capable of ocular demonstration, for no stars of small magnitude are visible to the naked eye when in proximity to the Moon when full; indeed, with the exception of the planets and stars of the first magnitude, all other celestial objects which occupy the region of the sky in which the full Moon is shining are lost in the effulgence of the lunar rays.

It is of importance that Satan's position in space, relative to the objects which he beheld when pursuing his hazardous journey, should be correctly understood. Milton locates Hell as being situated directly underneath the Universe, but 'Hell stretched far and wide,' and in his ascent from thence Satan's upward flight was probably not in a direct line with the great globe, for, when he emerged from the darkness of Chaos, he beheld 'far distant' the Empyreal Heaven, and underneath, the pendent sphere which presented the appearance of a minute star. Viewed from below and from such a distance, the Universe, in consequence of the absence of any perspective, could not have been perceived visibly

[1] In book x. 381, Milton describes Heaven as of quadrate form, and the Universe as orbicular.

detached from the Empyrean above—its contiguity would render it indistinguishable from the overhanging Heaven. Therefore, in order to obtain a view such as the poet describes, Satan must have made his ascent to the left, and reached an altitude sufficient to bring the Universe into outline so that it should be seen hanging entirely clear of the Heaven above. This is apparent, for when approaching the end of his journey through Chaos his position is described as:

> Coasting the wall of Heaven on this side night
> In the dim air sublime, and ready now
> To stoop with wearied wings and willing feet
> On the bare outside of this World, that seemed
> Firm land embosomed without firmament.
>
> iii. 71–5.

Eventually, Satan reaches the Universe, and alights on the surface of the enclosing spherical shell 'or first convex' at a point not far from the zenith. In describing its aspect and surroundings, the poet says:

> Meanwhile, upon the firm opacous globe
> Of this round World, whose first convex divides
> The luminous inferior orbs, enclosed
> From Chaos, and the inroads of Darkness old,
> Satan alighted walks. A globe far off
> It seemed; now seems a boundless continent,
> Dark, waste, and wild, under the frown of Night
> Starless, exposed, and ever threatening storms
> Of Chaos blustering round, inclement sky;
> Save on that side which from the wall of Heaven,
> Though distant far, some small reflection gains
> Of glimmering air less vexed with tempest loud.
>
> iii. 418–29.

This description of Satan's environment after having landed upon the surface of the sphere may well occasion surprise, for it reveals a condition of things different from what might have been expected. What seemed 'far off' a globe, is now a boundless continent, dark, waste, wild, and beat by perpetual storms of Chaos. The only portion of the great sphere that derived any light from the adjacent Empyrean was the side directed towards the wall of Heaven, which though 'distant far' afforded it some faint illumination. This aspect of the pendent Universe is incompatible with the description of its appearance as seen from a distance. Situated directly underneath the Empyrean, one would imagine that at least its upper hemisphere would have been radiant with light derived from the Heaven above. If it were not so illuminated, it would have been invisible from a distance; neither could it have presented the appearance of a globe as Satan approached it, for only its illuminated side was visible to his gaze; consequently its reflection would have created the visual impression, not of a circular disc but of a crescent having its convex edge directed towards the wall of Heaven.

Satan had wandered long on the surface of the enclosing spherical shell, when a gleam of light attracted his attention. Thither in haste he directs his steps, and—

> far distant he descries,
> Ascending by degrees magnificent
> Up to the Wall of Heaven, a structure high;
> At top whereof, but far more rich, appeared

The work as of a kingly palace gate,
With frontispiece of diamond and gold
Embellished: thick with sparkling orient gems
The portal shone, inimitable on Earth
By model, or by shading pencil drawn.
The stairs were such as whereon Jacob saw
Angels ascending, and decending, bands
Of guardians bright, when he from Esau fled
To Padan-Aram, in the field of Luz
Dreaming by night under the open sky,
And waking cried, *This is the gate of Heaven.*
Each stair mysteriously was meant, nor stood
There always, but drawn up to Heaven sometimes
Viewless; and underneath a bright sea flowed
Of jasper, or of liquid pearl.—iii. 501–19.

In this passage Milton describes how communication was maintained between Heaven and the new Universe. A mysterious ladder or stair, such as Jacob saw in his dream, with steps of gold ascending high, reached from the margin of the opening at the zenith of the sphere up to Heaven-gate. This structure was not always present: it was sometimes drawn up to Heaven and invisible, and at other times let down. Underneath the stairs there flowed a sea of jasper or of liquid pearl, which, when viewed through the aperture at the summit of the enclosing shell, was visible as a wide expanse of waters. In order to reconcile his system with the Mosaic cosmology, Milton identifies this sea with 'the waters above the firmament' (Gen. i. 6–10). Different interpretations have been hazarded in explanation of this passage, but it was generally upheld that the waters diffused over the Universe at the time of the creation were gathered together into two great

aggregations—one under the firmament, the other above the firmament. The waters under the firmament flowed over the surface of the Earth, and the waters above the firmament occupied the region of the Ninth Sphere which, in deference to the wishes of theologians, was called the Crystalline Sphere.

Milton appears to favour this distribution of the aqueous element, for in the argument prefixed to Book III we find that the poet, in alluding to the stairs, mentions the 'waters above the firmament that flow about it.' Milton describes the newly created Universe as

> another Heaven
> From Heaven-gate not far, founded in view
> On the clear hyaline, the glassy sea.—vii. 617–19.

and again:

> for as Earth, so he the World
> Built on circumfluous waters calm, in wide
> Crystalline ocean.—vii. 269–71.

The Jasper Sea[5] must be regarded as an arc or segment of Ninth Sphere; its waters having been visible as they flowed round the wide opening at the pole of the Universe. In describing the region of the Crystalline Sphere as a receptacle for the waters above the firmament, Milton adheres to the Biblical narrative of the Creation, but mars his cosmology, whilst at the same time he imparts charm and variety to his system by the addition of the bright-polar sea that flowed at the zenith of the sphere.

[5] See Frontispiece.

In continuation with the aperture in the 'first convex' or enclosing shell, a wide passage led down through the turning spheres, and terminated directly over the blissful seat of Paradise:

> A passage down to the Earth, a passage wide;
> Wider by far than that of after times
> Over Mount Sion, and, though that were large,
> Over the Promised Land to God as dear.
>
> iii. 528-31.

By means of the golden stairs and this wide passage, a highway was formed between Heaven and the terrestrial Paradise. A beam or shaft of light, streaming down from Heaven-gate, illumined the golden ladder and the jasper sea, and passing through the aperture mingled with the light of the Universe within. The all-pervading darkness was dispelled over this region, nor did it encroach beyond the margin of the spacious opening:

> So wide the opening seemed, where bounds were set
> To darkness, such as bound the ocean wave.
>
> iii. 538-39.

Angels on their visits to the Happy Garden descended, and in returning ascended by the passage and stairs towards which Satan wended his way. At the time when the Fiend approached the light the stairs were let down, and, standing on their lower steps, he paused for a moment to gaze upon the glorious sight that lay beneath him:

> Such wonder seized, though after Heaven seen,
> The Spirit malign, but much more envy seized,
> At sight of all this World beheld so fair.
> Round he surveys (and well might where he stood,

So high above the circling canopy
Of Night's extended shade) from eastern point
Of Libra to the fleecy star that bears
Andromeda far off Atlantic seas
Beyond the horizon; then from pole to pole
He views in breadth; and, without longer pause,
Down right into the World's first region throws
His flight precipitant, and winds with ease
Through the pure marble air his oblique way
Amongst innumerable stars, that shone
Stars distant, but nigh-hand seemed other worlds,
Or other worlds they seemed, or happy isles,
Like those Hesperian Gardens famed of old,
Fortunate fields, and groves, and flowery vales,
Thrice happy isles; but who dwelt happy there
He stayed not to inquire. Above them all
The golden Sun, in splendour likest Heaven,
Allured his eye.—iii. 552-73.

Situated above the region of dim shadow and accompanying night, Satan, in his wide survey, beholds the entire starry Universe in all its dimensions—all its concourses of glittering stars and shining orbs that circled round our yet invisible Earth lay open to his wondering gaze. He beholds it from east to west, or, 'from eastern point of Libra to the fleecy star ('Alpha Arietis') that bears Andromeda.' The constellations Libra and Aries being situated at opposite extremities of the celestial equator, Milton, with astronomical accuracy, defines the utmost limit of Satan's field of vision. Then from pole to pole or from north to south he takes a hurried glance, and without further pause precipitates himself through the wide opening down into the World's first region—the Ninth and Tenth Spheres. Having passed through those spheres, Satan must

have been unaware that the direct continuance of his journey downward would have landed him at the place in quest of which he wandered, or, Milton for poetical reasons decided that he should arrive at his destination by a more devious route, for, when he reached the region of the fixed stars he altered his perpendicular course and steered his way obliquely among those orbs. Although all the stars were relegated to the Eighth Sphere, they did not all occupy the same plane, but were distributed over the sphere in beds or layers at receding distances, so that some stars were more remote than others. The ancient and popular belief that the stars are other worlds inhabited by beings who live under happier conditions than are experienced on this Earth, finds delightful expression in Milton's description of Satan's progress among those luminaries. Surpassing in splendour all other visible objects, the golden Sun—a beautiful appellation which is sometimes applicable to the orb—attracts his attention :

Thither his course he bends,
Through the calm firmament (but up or down,
By centre or eccentric, hard to tell,
Or longitude), where the great luminary,
Aloof the vulgar constellations thick,
That from his lordly eye keep distance due,
Dispenses light from far. They, as they move
Their starry dance in numbers that compute
Days, months, and years, towards his all-cheering lamp
Turn swift their various motions, or are turned
By his magnetic [6] beam, that gently warms

[6] An allusion to Kepler's theory of planetary motion.

> The Universe, and to each inward part
> With gentle penetration, though unseen,
> Shoots invisible virtue even to the Deep;
> So wondrously was set his station bright.—iii. 573 87.

Satan on his voyage of discovery would seem to have become bewildered when traversing the sidereal regions, for, after having passed innumerable stars, he winged his flight in the direction of the Sun, but was unable to determine if his course were up or down, whether towards or from the centre of the Universe, or in longitude eastward or westward. Milton's inappreciative remark regarding the constellations indicates how little was known in his time of the component orbs that enter into the formation of these aggregations of stars. The supremacy accorded the Sun over all the other orbs of the firmament is quite in keeping with the Ptolemaic conception of the cosmos, for although regarded as a planet that occupied the Fourth Sphere, the orb not only dispensed light to our globe and to the other planets, but his rays shot through the beds of stars which they helped to illumine and penetrated even to the Deep.

In alluding to the starry dance in which the celestial orbs take part, the poet says that in moving towards his [the Sun's] all-cheering lamp they 'turn swift their various motions or are turned by his magnetic beam.' This remark applies not to the stars which were 'fixed' but to the planets, and it would appear that Milton has here departed, perhaps inadvertently, from the geocentric to the heliocentric

arrangement of the orbs that enter into the formation of the solar system, thereby making the Sun instead of the Earth the central body round which the planets revolved—a system different from the one he adopted for the requirements of his poem. Although Kepler discovered the ellipticity of the planetary orbits, he was unable to explain the motive force that guides and retains the planets in their paths. He imagined they were whirled round the Sun by the action of magnetic rays which emanated from the orb, and that between him and those bodies a mutually attractive influence was exerted resembling that manifested by dissimilar poles of magnets. It is apparent that Milton was conversant with Kepler's theory of planetary motion.

Having landed in the Sun, Satan, disguised as a cherub, beguiles the archangel Uriel, Regent of the Sun, who directs him to Earth, the abode of Man:

> Look downward on that globe, whose hither side
> With light from hence though but reflected shines:
> That place is Earth, the seat of Man: that light
> His day . . . .
> That spot to which I point is Paradise,
> Adam's abode; those lofty shades his bower.
>
> iii. 722-31.

The Fiend, having obtained the information he desired, renews his flight downward from the ecliptic to Earth, and alights on the summit of Niphates, a mountain of Armenia not far distant from the region in which was situated Paradise. Satan's arrival

on Earth proclaims the accomplishment of his adventurous journey.

Having described the means of communication between Heaven and the terrestrial Paradise, it will now be necessary, in order to embrace all the details of Milton's physical system, to make known how communication was established between Hell and the New Universe.

Following in the wake of Satan, Sin and Death, having flown from Hell-gate into the wild waste anarchy of Chaos, commenced to construct a bridge or causeway across the Deep, and in an incredibly short period of time completed a structure of prodigious length that spanned the vast Abyss. Its distant end they fastened securely to the surface of the spherical shell at the spot where Satan first alighted, and in proximity to the margin of the wide opening at the zenith of the sphere.

The construction of this wonderful viaduct is described by Milton with marked originality and vigour:

> Then both, from out Hell-gates, into the waste
> Wide anarchy of Chaos, damp and dark
> Flew diverse, and with power (their power was great)
> Hovering upon the waters, what they met
> Solid or slimy, as in a raging sea
> Tossed up and down, together crowded drove,
> From each side shoaling, towards the mouth of Hell:
> As when two Polar winds, blowing adverse
> Upon the Cronian Sea, together drive
> Mountains of ice, that stop the imagined way
> Beyond Petsora eastward, to the rich
> Cathaian coast. The aggregated soil

Death with his mace petrific, cold and dry,
As with a trident smote, and fixed as firm
As Delos, floating once; the rest his look
Bound with Gorgonian rigour not to move,
And with asphaltic slime; broad as the gate,
Deep as the roots of Hell the gathered beach
They fastened, and the mole immense wrought on
Over the foaming Deep high-arched, a bridge
Of length prodigious, joining to the wall
Immovable of this now fenceless World,
Forfeit to Death—from hence a passage broad,
Smooth, easy, inoffensive, down to Hell.
So, if great things to small may be compared,
Xerxes, the liberty of Greece to yoke,
From Susa, his Memnonian palace high,
Came to the sea, and over Hellespont
Bridging his way, Europe with Asia joined,
And scourged with many a stroke the indignant waves.
Now had they brought the work by wondrous art
Pontifical—a ridge of pendent rock,
Over the vexed Abyss, following the track
Of Satan, to the self-same place where he
First lighted from his wing, and landed safe
From out of Chaos, to the outside bare
Of this round World. With pins of adamant
And chains they made all fast, too fast they made
And durable.—x. 282–320.

The massive bridge or causeway formed a highway that enabled the Powers of Hell to reach the confines of their former blissful abode, and to distribute themselves over the Universe by occupying the different spheres, and inhabiting the regions of the air round our central Earth.

With the construction of the mighty viaduct, Milton's cosmological scheme may be regarded as complete. There now exists a permanent way that leads from the nether world up to the regions of light

—one of the three ways alluded to in the following citation:

> . . . and now in little space
> The confines met of Empyrean Heaven
> And of this World, and on the left hand Hell
> With long reach interposed; three several ways,
> In sight, to each of these three places led.
>
> x. 320 24.

The three[7] ways that met by the orifice in the spherical shell were: (1) the Golden Ladder, whose lower end rested near its margin; (2) the passage through the spheres down to Earth, which may be regarded as a prolongation of the aperture; (3) the Causeway from Hell, the terminal extremity of which was fastened to the surface of the convex shell in proximity to the wide opening. By means of those three ways, angels good and bad were enabled to visit the Mundane Universe, and the abode of Man.

Milton's cosmology may in some respects be regarded as his own. In order to meet the requirements of his poem he has amplified and adorned it with accessories derived from medieval and Biblical lore, supplemented by individual creations—the outcome of his own imaginative genius. In its greatness and comprehensiveness the poet's scheme stands unrivalled. The all-containing and uncontained Empyrean filled with the glory of visible Deity; the pendent Universe hung drop-like from its floor—an illumined globe floating in the great ocean of space; the Infernal World with its burning lake and

[7] See Frontispiece.

lurid flames sunk in the uttermost depths of Chaos, present to the reader's imagination a cosmological vision magnificent in its proportions and transcendent in its vastness.

Although the regions embraced in Milton's cosmological scheme possess a distinct configuration, yet it is by no means easy to comprehend the poet's conception of the spatial distances that intervene between. He says the prison of Hell is—

> As far removed from God and light of Heaven
> As from the centre thrice to the utmost pole.
>
> i. 74–5.

Milton means here, not the terrestrial pole, but the pole of the Universe. Consequently, the distance from Heaven-gate to Hell-gate is three semi-diameters of the great sphere; and therefore the pendent World occupies two-thirds of the space between Heaven and Hell. If we apply a literal interpretation to the lines just quoted it is difficult to conceive how the 'World' should have appeared so small—'in likeness of a star'—to Satan when it occupied so large a portion of the space in which he winged his flight. The frequency with which Milton introduces in his poems the mystical numbers 'three,' 'seven,' and 'nine,' lends weight to the surmise that the poet, instead of being exact, only intended to convey the impression of a vast and indefinite distance.

Milton describes the pendent Universe as 'fast by,' hanging in a golden chain from the floor of the Empyrean. The length of the chain is not stated, but as at certain times a golden ladder spanned the

interval, the space between the overhanging Heaven and the apex of the great globe must have been of very limited extent, and yet the poet mentions the wall of Heaven as being 'distant far,' so distant that it but faintly illumined the side of the sphere turned towards it. The poet is not quite consistent in what he says, and his description of the outside surface of the pendent globe does not harmonise with its surroundings nor with the notions usually associated with the Tenth Sphere.

In the elaboration of his physical system, Milton introduces three structures, viz. the Spherical Shell, the Causeway from Hell, and the Golden Ladder. They have already been described, but it is desirable that some further reference should be made to each.

The most striking of these is the hard material shell having an aperture at its apex, within which Milton enclosed the Universe. The poet does not favour us with a description of the formation of this structure such as he has given of the viaduct across the wide waste of Chaos, but, nevertheless, he appears to have regarded this opaque and impervious shell as a necessary adjunct to the physical configuration of the fabric of his poem. Cosmical conceptions, and the presence of transpicuous spheres of space were not alone sufficient for his purpose; in addition to those he required some concrete basis, some physical embodiment, in the attainment of which he enclosed the Universe within a hard material shell.

The uses of this structure may be enumerated

as follows: (1) It served as a protection to the Universe against the storms of Chaos; (2) it supported the golden ladder when let down from Heaven; (3) it afforded a firm foundation upon which rested the terminal extremity of the Causeway from Hell; (4) it provided Milton with a locality for his Paradise of Fools. These several uses testify to the importance of this 'first convex' in fulfilling the requirements regarded as essential by Milton in the elaboration of his poem.

Milton's ablest commentators have identified this 'first convex' with the Tenth Sphere or 'Primum Mobile.' The late Professor Masson in his 'Life of Milton' writes:

> It was not unpleasant to think of oneself as living on a ball fixed at the very centre of ten successive heavens or spheres of space wheeling variously round this ball; most with their single lights, but one radiant with innumerable lights and strongly shelled in by the Primum Mobile.

The same author, in his notes iii. 444–97 of the 'Paradise Lost,' says: 'Satan is on the outside of the Tenth Sphere or *Primum Mobile,* which *is* of firm opacous substance, though the Inferior Orbs which it encloses are invisible, or of transparent azure.' He adds:

> Although the outmost sphere is *a firm opacous shell,* there is one opening at least—a break or round hole at that topmost point of the shell where it is in near contact with, and, as it were, hangs from the Eternal or Empyrean Heaven. This point, of course, is exactly at the upper pole of the Starry Universe, where its axis ends in the Empyrean—for, as the shell is rotating, only at the pole could an opening be constant at the same place.

Milton in none of his poems identifies the Primum Mobile with anything material. In describing this sphere he makes no distinction between it and the other spheres; and in his long scientific discussion (viii. 15-178) with Raphael on the mechanism of the Heavens, it is apparent that he regarded the Tenth Sphere in the same light as he did all the other spheres, viz. a rapidly revolving zone of transpicuous space. The poet describes the Primum Mobile as the 'first high-moving sphere,' 'that swift nocturnal and diurnal rhomb,' 'the wheel of day and night.' To the spheres he imparted speed 'almost spiritual' —'speed, to describe whose swiftness number fails,' but the most rapid of them all was the Primum Mobile.

When Satan landed upon the 'first convex' he found himself on *terra firma*—a boundless continent, dark, waste and wild—the surface of the spherical shell that enclosed the Universe, at the apex of which there existed a wide circular opening. The presence of this material structure seems so strange and unnatural that one is justified in concluding that in no circumstances can it be identified with the Primum Mobile, but must be regarded as one of the creations of Milton's imagination. In support of this assertion we find in the remarkable digression (iii. 440-97) in which Milton describes the upward flight from Earth of the concourse of eccentric and vain individuals who long after the Fall attempted to reach Heaven by their own efforts, the most pointed allusion to the Ptolemaic system contained in his

poem, but in expressing himself he associates nothing material with the Primum Mobile :

> They pass the Planets Seven, and pass the Fixed,
> And that Crystalline Sphere whose balance weighs
> The trepidation talked, and that First Moved.
>
> iii. 481-83.

They pass the first seven spheres, then the Eighth Sphere or that of the fixed stars ; then the Ninth or Crystalline Sphere, to which was attributed a libratory or trembling motion in order to account for certain apparent irregularities of motion among the stars ; and finally they pass the Tenth Sphere or 'Primum Mobile.' This outermost sphere having been passed, the orifice in the spherical shell is reached and above is seen Heaven-gate. The pilgrims, when about to climb the golden ladder that led to Heaven's wicket, are caught by violent cross-winds—gusts of Chaos—and blown with all their grotesque and trumpery belongings ten thousand leagues awry 'over the back-side of the World,' or on to the surface of the enclosing shell, a limbo large and wide designated by Milton the Paradise of Fools.

Had Milton associated any rotatory motion with this spherical shell he would not have fastened to its surface the terminal extremity of the bridge from Hell—

> Of length prodigious, joining to the wall
> Immovable of this now fenceless World.
>
> x. 302-303.

A stable and secure foundation which should be motionless was essential for such a purpose. Neither

would the poet have made use of this structure to support the lower extremity of the Golden Ladder had it not been stationary. A revolving sphere, even of material consistence, would have been useless for the purposes mentioned. No hollow sphere or concave structure could maintain its configuration if subjected to a fractional part of the speed required of the Primum Mobile; it would be completely pulverised and its substance reduced to cosmic dust.

The existence of the spherical shell must be regarded as a concrete reality, but it formed no part of the Primum Mobile, and, notwithstanding its numerous and varied uses, it can only be regarded as an unnatural and incongruous addition to the system upon which Milton reared the fabric of his poem.

The Bridge or Causeway that connected the nether world with the New Universe is purely a Miltonic conception, and, like the spherical shell, was regarded by the poet as a necessary adjunct to the physical arrangement of his system. But it does not appear very obvious why such a massive and ponderous viaduct should have been required for the passage to and fro of spiritual beings who in their movements cannot be likened to pedestrians. Some aery filamented structure would have borne the nimble tread of those angelic beings, or, as incorporeal creatures, they might have been able to transport themselves across the intervening abyss without any adventitious aid. But the storms of Chaos had

to be combated, hence the necessity for a structure that should be capable of withstanding the strain and stress of the surging elements. The mighty Causeway fulfilled the visionary purpose for which it was intended, but as a fabric designed to meet the requirements of the poem it may well be regarded as grotesque.

The mysterious Stair or Ladder that scaled the interval between Heaven-gate and the pole of the Universe is less open to criticism than the other structures to which allusion has been made. Selecting the vision of Jacob's ladder as his source of inspiration, the poet's description of this celestial means of access harmonises with conceptions based upon the existence of a thing tangible and material, and which might yet be regarded as symbolical of the splendour of the Empyrean. The mystic Ladder with its steps of gold, which, by celestial touch, could be lowered and raised at will, formed a fit approach to the kingly palace gate that guarded the entrance to the Eternal Mansions.

If we regard Milton's cosmological scheme in its entirety, we are impressed with its vastness, with its majestic proportions, and with the sublimity of the poet's conception of the regions embraced within the sphere of universal infinitude. In the composition of his great epic he doubtless realised the difficulty of his undertaking, for he had to rely upon his creative imagination in giving physical embodiment to things situated beyond the reach of science and too vague to come within the range of human comprehension.

He had to materialise abstract conceptions, and impart firmness and stability where nothing tangible existed. If in the attainment of these, Milton has introduced in his poem 'the impossible, the unnatural, and the grotesque,' and by so doing made himself amenable to adverse criticism, it must be remembered that in the exercise of his free imagination he had a right to indulge in any phantasmagorial visions that his poetic fancy might suggest.

CHAPTER III

MILTON'S ASTRONOMICAL KNOWLEDGE

ANY studious reader of Milton's 'Paradise Lost' cannot fail to perceive how largely astronomy enters into the narrative of the poem, and with what frequency astronomical allusion embellishes its pages. That the sublimest of poets should have found in the loftiest of sciences fit subject-matter for the elaboration and adornment of his great epic is only what might have been expected; and, should we not be altogether justified in calling Milton an 'astronomer-poet,' yet it will be of interest to ascertain the extent of his astronomical knowledge, and its application in the portrayal of his chosen theme.

Milton (1608–1674) lived in a transitional period as regards astronomical theories. The age, too, in which he wrote formed an epoch in the history of astronomy, coinciding as it did with the conflict that was being waged between the upholders of the old Ptolemaic or geocentric, and the new Copernican or heliocentric systems of the Universe. Copernicus promulgated his theory in 1543, but it was marred

by numerous imperfections and inaccuracies that retarded its acceptance by many who would otherwise have been inclined to adopt it. Consequently, it made but slow progress; nor was it until near the middle of the seventeenth century that it seriously threatened the supremacy of the older system.

Tycho Brahé, the eccentric Dane whose powers of observation greatly excelled his reasoning capacity, repudiated the Copernican hypothesis, but his coadjutor Kepler ardently supported it, and by his discovery of the laws of planetary motion dealt the Ptolemaic system a blow that made it totter to its fall. Galileo, and other distinguished scientists who resided on the Continent, also supported the Copernican theory, and the more advanced astronomical views.

In England few men of eminence had at this period embraced the new astronomical doctrines, and up to and beyond the middle of the seventeenth century the majority of those who represented the intellect and learning of the country professed their adherence to the old Ptolemaic beliefs. Among Milton's contemporaries, Hobbes was the only person of literary distinction who upheld the more recent views. Bacon persistently rejected them, as did also many other men of learning who lived at that time. In contrast with this general neglect of the Copernican hypothesis, we learn that Horrox, the young Lancashire astronomer, gave it his hearty support, and in a treatise which he wrote in defence of Kepler's astronomy, enthusiastically upheld the new doctrines

The genius of Newton had not yet shed its lustre abroad, for his great scientific career was only beginning, and his philosophic communications had not yet been communicated to the world. With the progress of scientific discovery the new doctrines slowly but surely supplanted the older beliefs, for the overthrow of a system so ancient and so venerable as the Ptolemaic required a lengthened period of time for its accomplishment.

From his youth up to his thirtieth year, Milton may be regarded as having been a consistent Ptolemaist. We have no evidence that he paid any attention to the Copernican hypothesis, or bestowed upon it any serious thought, or that it exercised any influence upon his mind in modifying his belief in the older theory. In 'Arcades,' 'Comus,' 'Lycidas,' and other minor poems, which were composed prior to and during the 'Horton period' of his life, we find no traces of Copernicanism, no evidence which would lead us to imagine that he doubted the accuracy and correctness of the Ptolemaic system with its attractive arrangement of crystalline spheres revolving round the stationary Earth; his mind rested secure in this belief, the outcome of the collective wisdom of astronomers and philosophers who lived and flourished centuries before. But as Milton grew older we have reason to believe his Ptolemaism became greatly modified, and that in his later years he renounced it entirely in favour of Copernicanism.

After the death of his mother, which occurred

in 1637, Milton visited the Continent and made a tour of the cities of Italy. When on his travels he met and conversed with men of eminence who upheld scientific doctrines in advance of those with which he was familiar. Among them was the famous Galileo, whom he visited during his stay at Florence. it is unknown what subjects were discussed in this memorable interview between the aged astronomer and the young English poet, but we can well believe that Milton came away impressed with the reasonableness of the Copernican beliefs. On his return to England in 1639 Milton, having taken up his pen in defence of the Commonwealth, bade a long farewell to poetry, and, except for an occasional sonnet, his muse remained silent for wellnigh a quarter of a century.

It was during this period, when Milton had laid aside his 'singing-robes,' that the conflict between the upholders of the systems of Ptolemy and of Copernicus had reached a critical stage. Many of the errors and complications associated with the Copernican system on its promulgation were being gradually eliminated, or successfully elucidated. Uniform circular motion was found to be non-essential; cycles and epicycles were abolished, and other cumbersome entanglements which marred the harmonious plan upon which the system was founded were discarded. Slowly but surely the new doctrines overcame the prejudices of those who were opposed to them, and with the advancement of the science of astronomy much new information was obtained

which tended to confirm the accuracy of the Copernican theory.

The exploration of the celestial regions with the recently invented telescope—first undertaken by Galileo, who made many wonderful discoveries, and afterwards vigorously prosecuted by his successors with increased optical power—disclosed the vast and apparently illimitable extent of the sidereal heavens. However far the instrument was capable of penetrating space, an unbroken expanse of stars and starry archipelagos met the gazer's eye; nor did they diminish in number with receding distances, and when the visual limit was reached, there still remained the conviction that beyond there were other star-depths, unknown and unfathomable. Within the solar system many discoveries were made with the telescope, which testified to the correctness of the Copernican hypothesis. By means of the instrument it was ascertained that the Sun rotates on his axis, and that the planets Venus, Mars, and Jupiter possess a similar motion—convincing evidence that the other planets, including the Earth, also rotate on their axes. Transits of Mercury and of Venus were observed as those planets passed across the Sun's disc; these, with the phases displayed by Venus when pursuing her path, afforded conclusive evidence of the heliocentric arrangement of our system. Improved methods of research enabled astronomers to determine with greater exactness the magnitudes and dimensions of the celestial orbs, and also the extent of the distances which intervene

between them—distances far greater than were imagined It then became apparent that the Earth is but one of a retinue of worlds which derive their light and heat from the Sun, and that our globe with her single satellite is surpassed in mass and importance by some of her sister planets.

Milton, like his poet-predecessor Dante, possessed an intimate acquaintance with all the science and philosophy of his age. His elegant scholarship, vast erudition, and comprehensive knowledge were only excelled by his genius, which was universal. When in 1658 he commenced to write his immortal epic, the conflict which had so long been waged between the supporters of the rival astronomical systems of Ptolemy and of Copernicus had reached a crisis which terminated with the overthrow of the more ancient one. The application of Kepler's Laws to the motions of the planets, together with the many and important discoveries made with the telescope, afforded conclusive evidence that the new and nobler conception of the cosmos must prevail. Consequently, among the well-informed, the Copernican System was accepted as the true theory of the Universe, although the Ptolemaic still retained its hold on the popular mind. In this important controversy, Milton was in advance of many of his contemporaries, and perceived the far-reaching effect which the new beliefs would have upon the science of the future. Standing between the old and the new on the verge of modern achievement, and possessing a thorough knowledge of both theories,

Milton, in the exercise of his free imagination, saw with prophetic vision beyond the known limits of the Universe, things that were long hidden from other men, and although for poetical reasons he chose the older and more picturesque system for his great epic, yet he perceived and appreciated the beauty of the Copernican and knew that it must ultimately prevail.

The importance which Milton attached to this great astronomical controversy becomes apparent on referring to the 'Paradise Lost' (Book viii. 15–178). Here we find recorded a long philosophic discussion between Adam and the archangel Raphael in which the respective merits of both systems are fully discussed. It would appear strange to us that Adam—the first of men—should have possessed the requisite scientific knowledge that enabled him to comprehend all that the Angel had to tell, or that he should have been capable of suggesting, as if by intuition, a theory of terrestrial motion that his descendants in ages long after were unable to verify. This display of scientific wisdom on the part of our great progenitor is not in harmony with the preconceived notions usually associated with the happy pair who dwelt in the Garden of Eden. To their upward gaze the orbs of Heaven appeared to be in ceaseless motion; the solid Earth upon which they stood was alone immovable and at rest. Day after day they observed the Sun pursue his steadfast course with unerring regularity; his rising in the east accompanied by the rosy hues of morn; his meridian

splendour; and his sinking in the west mid the refulgent glories of departing day. With the advent of night they behold the Moon now increasing, now waning describe her irregular path athwart the sky, also to disappear in the west, whilst like the hosts of an army marshalled in loose array the constellations with stately motion traversed their nocturnal arcs circling the pole of the heavens.

In attributing to Adam such wisdom and intelligence, Milton introduces the improbable in his poem, but in so doing he had an object in view, for it enabled him to unburden his mind, and to express with freedom his views respecting matters in dispute. If, in this scientific discussion, we shall learn that Milton ridicules the older theory or favours the Copernican hypothesis, we may then assume that his adoption of the Ptolemaic system for the requirements of his poem need be regarded with no greater seriousness than his creation of the spherical shell that enclosed the Universe, or the viaduct that spanned the abyss of Chaos.

This interesting colloquy is commenced by Adam who addresses his Angel-guest as follows:

> When I behold this goodly frame, this World
> Of Heaven and Earth consisting, and compute
> Their magnitudes—this Earth a spot, a grain,
> An atom, with the firmament compared
> And all her numbered stars, that seem to roll
> Spaces incomprehensible (for such
> Their distance argues, and their swift return
> Diurnal) merely to officiate light
> Round this opacous Earth, this punctual spot.
> One day and night, in all their vast survey

Useless besides—reasoning I oft admire
How Nature, wise and frugal, could commit
Such disproportions, with superfluous hand
So many nobler bodies to create,
Greater so manifold, to this one use,
For aught appears, and on their Orbs impose
Such restless revolution day by day
Repeated, while the sedentary Earth,
That better might with far less compass move,
Served by more noble than herself, attains
Her end without least motion, and receives,
As tribute, such a sumless journey brought
Of incorporeal speed, her warmth and light:
Speed, to describe whose swiftness number fails.
viii. 15–38.

It is patent that Adam possessed the eye of an astronomer and the mind of a philosopher, so clearly and tersely does he express himself in discussing the phenomena of the Heavens. In support of his argument he emphasises two points: (1) The minuteness of the Earth, which he describes as a spot, a grain, an atom, when compared with the surrounding universe *and the orbs that enter into its formation*; (2) The inconceivable velocity with which it was necessary for those orbs to travel in order to accomplish a diurnal revolution round the stationary globe. He expresses his surprise that Nature, 'wise and frugal' should have created so many nobler bodies 'greater so manifest' who fulfilled their only apparent function by circling unceasingly round the Earth—'this punctual spot.' Adam does not propound any other hypothesis; apparently he is unaware of the difference between planets and stars, nor has he any notion of the heliocentric arrangement of the

orbs which form the solar system. What appears preposterous to him is the Ptolemaic belief that the entire Heavens should accomplish a diurnal revolution round the Earth, when by imparting motion to the Earth herself similar phenomena could be brought about without the necessity of imposing such restless revolution upon the other celestial orbs.

The Angel, having listened to Adam's argument, expresses approval of his desire to acquire knowledge, but answers him dubiously, and at the same time subjects the Ptolemaic system to severe and adverse criticism :

> To ask or search I blame thee not ; for Heaven
> Is as the Book of God before thee set,
> Wherein to read his wondrous works, and learn
> His seasons, hours, or days, or months, or years.
> This to attain, whether Heaven move or Earth
> Imports not, if thou reckon right ; the rest
> From Man or Angel the great Architect
> Did wisely to conceal, and not divulge
> His secrets, to be scanned by them who ought
> Rather admire. Or if they list to try
> Conjecture, he his fabric of the Heavens
> Hath left to their disputes, perhaps to move
> His laughter at their quaint opinions wide
> Hereafter, when they come to model Heaven,
> And calculate the stars ; how they will wield
> The mighty frame ; how build, unbuild, contrive
> To save appearances ; how gird the sphere
> With centric and eccentric scribbled o'er,
> Cycle and epicycle, orb in orb.—viii. 66-84.

Raphael remarks to Adam that it is a matter of no great significance whether Heaven move or Earth, so long as he is capable of perceiving and

appreciating the power and wisdom of the Creator as displayed in His works. He extols the sapience of the great Architect who wisely did conceal from man or angel his secret of the Heavens; and they who try conjecture are left to their own disputes and quaint opinions—perhaps to move His laughter—'when they come to model Heaven and calculate the stars.' The Angel then holds up to ridicule the devices which Ptolemaic astronomers were compelled to adopt in order to 'save appearances,' or, in other words, explain certain irregularities of motion among the celestial orbs. Ancient astronomers upheld the belief that all the heavenly bodies moved in circles, this form of motion having been regarded by them as the most perfect and therefore best adapted for celestial movement. Even Copernicus, in propounding his new theory of the Universe, retained the notion of uniformly circular motion. But it was known from remote antiquity that the simple circular motion *round the Earth of eight or even ten spheres* with their contents—no matter how much their speed might vary relatively to each other—would not account for all the observed phenomena associated with motion in the Heavens. For example, the Sun when describing a certain segment of his orbit was observed to travel with greater speed than when he traversed the corresponding opposite portion. The planets too were perceived to move irregularly. Instead of appearing to maintain a progressive motion in the order of the signs, which they invariably do, they were observed at times to become

stationary for a short interval, and at other periods to affect a retrograde movement on the sphere.

In order to account for these irregularities of motion among the celestial orbs, astronomers had recourse to two devices, viz. that of the *Eccentric*, and that of the *Epicycle*. It was assumed that all the spheres need not be concentric, i.e. need not have the Earth as their exact centre, but that the central point round which some of them revolved might be eccentric, or situated a short distance from the Earth. Consequently, the distance of the revolving body from the Earth would vary according to its position in its orbit; when near the Earth its velocity would appear greater than when more remotely situated. By this arrangement the accelleration and retardation of the Sun's motion when occupying opposite extremities of his orbit was ingeniously explained. Again, the alternate progressive and retrograde motion of the planets was accounted for by assuming that a planet was not fixed in the circumference of its revolving sphere or cycle, but moved in an epicycle or small circle that revolved round a fixed point in the larger circle. This epicycle in its revolution carried with it the planet, which when beyond the circumference of its cycle would have a progressive, and when within it a retrograde, motion.

By means of these two devices, Ptolemaic astronomers were able to account in a fairly satisfactory manner for all the phenomena associated with solar and planetary motion. But more accurate observa-

tions brought to light discrepancies that could only be explained by multiplying the number of the spheres and by piling epicycle on cycle, thus creating a most complicated entanglement and hastening the downfall of a system that is now remembered as a belief of bygone ages.

It may here be observed with what conciseness and brevity Milton enumerates the expedients which Ptolemaists had recourse to in bolstering up their system. They 'gird the sphere with centric and eccentric scribbled o'er'—a rather contemptuous way of alluding to the intricacy created by some spheres being centric and others eccentric. 'Cycle and epicycle'; wheel within wheel; and 'orb in orb'—the multiplication of spheres—other devices adopted in the attainment of the same object. Ptolemy set some five dozen spheres in motion, and in motion they remained until shattered by Copernicus.

After his scathing criticism of the mechanism of the Ptolemaic system, Raphael continues his reply to Adam's inquiry respecting motion in the Heavens, but expresses himself ambiguously:

> Already by thy reasoning this I guess,
> Who art to lead thy offspring, and supposest
> That bodies bright and greater should not serve
> The less not bright, nor Heaven such journeys run,
> Earth sitting still, when she alone receives
> The benefit. *Consider, first, that great*
> Or bright infers not excellence: the Earth,
> Though, in comparison of Heaven, so small,
> Nor glistering, may of solid good contain
> More plenty than the Sun that barren shines,

Whose virtue on itself works no effect,
But in the fruitful Earth; there first received,
His beams, unactive else, their vigour find.
Yet not to Earth are those bright luminaries
Officious, but to thee, Earth's habitant.
And for the Heaven's wide circuit, let it speak
The Maker's high magnificence, who built
So spacious, and his line stretched out so far,
That Man may know he dwells not in his own—
An edifice too large for him to fill,
Lodged in a small partition, and the rest
Ordained for uses to his Lord best known.
The swiftness of those circles attribute,
Though numberless, to his omnipotence,
That to corporeal substances could add
Speed almost spiritual. Me thou think'st not slow,
Who since the morning-hour set out from Heaven
Where God resides, and ere mid-day arrived
In Eden, distance inexpressible
By numbers that have name. But this I urge,
Admitting motion in the Heavens, to show
Invalid that which thee to doubt it moved;
Not that I so affirm, though so it seem
To thee who hast thy dwelling here on Earth.
God, to remove his ways from human sense,
Placed Heaven from Earth so far, that earthly sight,
If it presume, might err in things too high,
And no advantage gain.—viii. 85–122.

Notwithstanding his adverse criticism of the Ptolemaic system the angel Raphael endeavours to persuade Adam that his reasoning as regards celestial motion may not be entirely convincing, and traverses his argument by questioning the validity of his surmise that bodies of greater size and brightness should not serve those that are smaller and opaque, or that Heaven should run such journeys while the Earth remained at rest. He argues that great or

bright infers not excellence, and that the Earth, though small when compared with Heaven, may contain more solid good than the 'Sun that barren shines,' whose beams produce no beneficial effect except when directed upon the fruitful Earth. He reminds Adam that these bright luminaries minister not to Earth, but to himself 'Earth's habitant'; and directs his attention to the magnificence and extent of the surrounding Universe, of which he occupies so small a portion. The diurnal swiftness of the spheres Raphael attributes to God's omnipotence that to material bodies 'could add speed almost spiritual.' After alluding to his rapid flight from Heaven—'a distance inexpressible by numbers that have name'—the Angel, in order to escape from a dilemma, suggests to Adam that God placed Heaven so far from Earth, that Man, if he presumed, might err in trying to attain to things too high, the knowledge of which would be of no advantage to him.

Hitherto the discussion carried on by Adam and Raphael concerning celestial motion has been based upon the merits of the Ptolemaic system, the fundamental principle of which embraced the belief in the diurnal revolution of the entire Heavens round the stationary Earth. But now the Angel unexpectedly finds Adam food for reflection by propounding a new theory of the Universe more in harmony with the views recently expressed by our great sire:

What if the Sun
Be centre to the World; and other stars,
By his attractive virtue and their own
Incited, dance about him various rounds?

Their wandering course, now high, now low, then hid,
Progressive, retrograde, or standing still,
In six thou seest; and what if seventh to these
The planet Earth, so steadfast though she seem,
Insensibly three different motions move?
Which else to several spheres thou must ascribe,
Moved contrary with thwart obliquities.
Or save the Sun his labour, and that swift
Nocturnal and diurnal rhomb supposed,
Invisible else above all stars, the wheel
Of day and night; which needs not thy belief,
If Earth, industrious of herself, fetch day,
Travelling east, and with her part averse
From the Sun's beam meet night, her other part
Still luminous by his ray. What if that light,
Sent from her through the wide transpicuous air,
To the terrestrial Moon be as a star,
Enlightening her by day, as she by night
This Earth—reciprocal, if land be there.
Fields and inhabitants? Her spots thou seest
As clouds, and clouds may rain, and rain produce
Fruits in her softened soil, for some to eat
Allotted there; and other Suns, perhaps,
With their attendant Moons, thou wilt descry,
Communicating male and female light,
Which two great sexes animate the World,
Stored in each orb perhaps with some that live.
For such vast room in Nature unpossessed
By living soul, desert and desolate,
Only to shine, yet scarce to contribute
Each orb a glimpse of light, conveyed so far
Down to this habitable, which returns
Light back to them, is obvious to dispute.—viii. 122–58.

In suggesting a new theory of celestial motion, Raphael hints to Adam that the Sun may be centre to the 'World.' In Milton's day astronomical phraseology was indefinite and vague, and the 'World' here signifies not our globe, but the entire

starry universe. It is possible that the poet may have regarded the Sun as the central orb of the universe, for in his time little was known of the stars, and as part of the cosmos they were held to be of small moment (iii. 576–78).

The Angel, in describing this heliocentric system, otherwise known as the Copernican, alludes to the positions and motions of certain 'stars' when accomplishing their revolutions round the Sun. Sometimes they are high in the sky, sometimes low, and at other times invisible. Their motion is usually progressive, but at certain points in their orbits they appear stationary for a brief interval. At other periods their onward motion is reversed, and they seem to retrograde or travel backward on the ecliptic. These are the planets [1] whose different aspects and motions can be explained in conformity with the Copernican hypothesis.

The Angel informs Adam that six planets [2] can be seen, and suggests that the Earth may be a seventh,

[1] If viewed from the Sun, all the planets would be seen to describe their true paths round the orb in the order to the signs of the zodiac; their motion would invariably be in the same direction, and any increase or decrease in their speed as they approached perihelion or aphelion would be real; but when observed from the Earth, which is itself in motion round the Sun, the effect created would at certain times be quite different, and all the variations of motion which the poet so concisely describes would, on close observation, become perceptible. These can be explained as being due to the combined motions of the Earth and planets which are together travelling round the Sun with different velocities, and in orbits of unequal dimensions.

[2] The planets were five in number, viz. Mercury, Venus, Mars, Jupiter, and Saturn, but Milton, by including the Moon as a planet, makes the number six. Correctly speaking, the Moon is the Earth's satellite and accompanies her primary on her annual journey round the Sun.

who, although apparently at rest, yet possesses three different motions. These are (1) her diurnal rotation on her axis; (2) her annual journey round the Sun; (3) a slow revolution of the terrestrial pole round that of the ecliptic, which motion accounts for the Precession of the Equinoxes. Unless these three motions are accomplished by the Earth, they must needs be ascribed to several spheres moving in contrary directions and crossing each other obliquely. If terrestrial, these motions would save the 'Sun his labour,' i.e. his daily journey round the Earth; nor would it be necessary to believe in the existence of that invisible wheel or 'rhomb,' the 'Primum Mobile' that carried with it the nine inner spheres round the Earth in twenty-four hours. This sphere could also be dispensed with if the Earth, by rotating on her axis from west to east, should meet the Sun and thus enjoy day in the hemisphere directed towards him, her other, averted from his rays, being enveloped in night.

With the adoption of the Copernican hypothesis the spheres ceased to revolve; the stars became motionless, and were called 'the fixed' in order that they might be distinguished from other celestial bodies whose movements could be more readily perceived. The hitherto steadfast Earth joined in the dance of her sister planets, and, although deprived of her pre-eminence among other orbs, may yet be regarded as the most important habitable world that circles round the Sun.

After alluding to other phenomena, to which

reference will be made elsewhere, the angel Raphael, in bringing this elevated and philosophic discourse to a conclusion, expresses himself in the following beautifully poetical summary:

> But whether thus these things, or whether not—
> Whether the Sun, predominant in Heaven,
> Rise on the Earth, or Earth rise on the Sun;
> He from the east his flaming road begin,
> Or she from west her silent course advance
> With inoffensive pace that spinning sleeps
> On her soft axle, while she paces even,
> And bears thee soft with the smooth air along—
> Solicit not thy thoughts with matters hid;
> Leave them to God above; him serve and fear.
>
> viii. 159-67.

Notwithstanding the strictly neutral attitude assumed by the angel Raphael when touching upon the salient features of the Ptolemaic and Copernican systems, a careful perusal of the passages just quoted will enable the reader to arrive at no uncertain conclusion as to what was Milton's astronomical creed. The poet's thorough knowledge of the details of both systems enabled him to exercise a wise discrimination in judging of their respective merits, and to arrive at a sound conclusion as to which theory was deserving of support. The views expressed by Adam regarding celestial motion, and his well-reasoned and convincing arguments in combating the belief that the entire Heavens should accomplish a diurnal revolution round the stationary Earth, may be regarded as indicating Milton's own convictions. The onslaught made by Raphael on the Ptolemaic system, and his merciless criticism of

the devices which Ptolemaic astronomers had recourse to in order to explain certain celestial phenomena, also indicate that the poet was fully cognisant of the false hypotheses upon which this venerable system was founded. But Milton chose the Ptolemaic system for the physical requirements of his 'Paradise Lost,' and this choice on the part of the poet accounts for the indecision which pervades the whole discussion. It would seem as if Milton were anxious to express his opinions respecting the merits of the controversy that was being waged between the upholders of the Ptolemaic and Copernican systems, but in such a way as not to mar the symmetry of his poem. Milton endeavoured to avoid the introduction in his 'Paradise Lost' of another system that would have made the Ptolemaic appear incredible and absurd; hence Raphael's indecision when replying to Adam's inquiry respecting celestial motion, and his allusion to the Copernican system merely as a supposition. In the concluding summary Milton takes up a position of strict neutrality; the exigencies of the poem necessitated this attitude on his part, for he was desirous of saying nothing that would adversely affect the physical arrangement of the system upon which he reared the fabric of his great epic. Finally, when we come to weigh up the poet's utterances—his unsparing criticism of the Ptolemaic system, and his necessarily tentative approval of the Copernican, one conclusion only can be arrived at, viz. that Milton was no believer in a stationary Earth and a revolving Universe.

After his return from the Continent in 1639, Milton opened a small private academy in Aldersgate, London. Included in the list of subjects which he selected for the instruction of his youthful pupils were mathematics and astronomy. The text-book which he used in teaching astronomy was called 'De Sphaera,' a small work written by Joannes Sacrobosco (John Holywood), an English mathematician who lived and died at Paris in the thirteenth century. The book is an epitome of a portion of Ptolemy's 'Almagest,' and treats of the terrestrial globe, of the celestial sphere, of circles great and small, of the rising and setting of the stars, and of the motions of the planets. As a manual of astronomy it enjoyed great popularity in the Middle Ages, and is reported to have passed through as many as forty editions. It was entirely Ptolemaic in its teaching.

Milton's knowledge of the configuration of the celestial and terrestrial spheres, and of the great circles traced thereon, may be attributed to his familiarity with this book. In his description of Satan's flight after his altercation with Gabriel in Paradise, the poet mentions three of these circles:

> The space of seven continued nights he rode
> With darkness; thrice the equinoctial line
> He circled; four times crossed the car of Night
> From pole to pole, traversing each colure.—x. 63-6.

Of the seven days occupied by Satan in his peregrination round the Earth, three were spent in circling the equinoctial or equator, travelling with

night from east to west and thus avoiding day; *four in moving from pole to pole or from north to* south and back. In accomplishing this part of his journey, Satan is described as 'traversing each colure.' The colures are two great circles that intersect the poles, and the equinoctial and solstitial points respectively. The circle that passes through the vernal equinox is called the Equinoctial Colure, and that passing through the summer solstice the Solstitial Colure. Milton appears to have been familiar with these circles. The term colure is now obsolete.

The Meridian is the name given to another great circle on the celestial sphere that passes through both poles of the heavens, and also through the zenith and nadir of any place on the Earth's surface. Consequently, every locality on the globe has its own meridian, and all places under the same meridian have the same longitude. Celestial bodies attain their greatest altitude on the sphere when they come upon the meridian, and it is midday at any place on the Earth's surface when the centre of the Sun is on the meridian of that place.

Milton repeatedly alludes to the meridian. He describes the Sun as occupying his 'meridian tower,' and refers to his 'meridian heat.' Gabriel, in response to Uriel's warning, informs him that since 'meridian hour' no creature had entered Paradise.

Milton's knowledge of the constellations was both accurate and comprehensive. He probably knew the names of all the northern constellations—

twenty in number—and with several of those of the southern hemisphere he was also familiar. With many, their configuration, their relative position on the sphere, and the objects of interest situated in each of them were well known to him, for Milton was an interested observer of the heavens, and fully appreciated the nocturnal beauty of the starlit sky. The poet was well acquainted with the twelve *zodiacal constellations, and in describing the apparent* upward and downward motion of the Sun in the heavens he mentions the names of nine of them. They are, Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, and Capricornus. In addition to those, four other constellations are referred to in the 'Paradise Lost,' viz. Andromeda, Centaurus, Ophiuchus, and Orion, making the total number thirteen. Ursa Major, familiarly known as the Great Bear, is the only other constellation to which Milton alludes in his poems. It is one of the circumpolar constellations that never sets, but circles continuously round the pole. The poet says:

> Or let my lamp, at midnight hour,
> Be seen in some high lonely tower,
> Where I may oft outwatch the Bear.—Il P. 85–7.

Outwatching the Bear means sitting up after midnight until the morning light renders the stars invisible.

Andromeda, the chained lady, who was rescued by the valiant Perseus from the sea-monster Cetus, *is described as being borne by Aries. In the nightly* procession of the constellations, Andromeda, in the

autumn, occupies a position above Aries, and would seem to be carried onward by the latter. Milton, in the well-known lines (iii. 555-60), alludes to this aspect of the constellation.

Centaurus is the constellation in which our Sun, as a star, would be included, Alpha Centauri being his nearest neighbour. It is situated in the southern hemisphere.

Ophiuchus is a large constellation in the south-eastern sky, in which Milton locates a comet that extends its entire length—a distance of about forty degrees.

Orion, the finest constellation in the heavens, must have been a familiar object to the poet. It arrives on the meridian in winter, and is conspicuous as a brilliant assemblage of stars. The constellation represents an armed warrior or hunter holding in his right hand a massive club, and having on his left arm a shield of lion's hide. A triple-gemmed belt encircles his waist from which is suspended a glittering sword tipped with a bright star. The two brilliants, Betelgeux and Bellatrix, form the warrior's shoulders, and the bright star Rigel marks the position of his advanced foot.

The Orion stars appear above the horizon in November; in February the constellation in full glory lies due south close to the meridian, and towards the end of April disappears low down in the west.

In ancient times the rising and setting of Orion was believed to be accompanied by stormy weather. In the following lines Milton ascribes the tempestuous

condition of the elements to the presence of the constellation:

> . . . when with fierce winds Orion armed
> Hath vexed the Red-Sea coast, whose waves o'erthrew
> Busiris and his Memphian chivalry.—i. 305-7.

With the zodiacal constellation Libra (the Balance), Milton associates a lofty poetical conception which he identifies with the Homeric notion of the golden scales in which God first weighed the Earth and all created things, and with them decides the issue of all uncertain events. Satan, by means of this celestial sign, is warned of his fate should he engage in combat with Gabriel in Paradise:

> The Eternal, to prevent such horrid fray,
> Hung forth in Heaven his golden scales, yet seen
> Betwixt Astraea [3] and the Scorpion sign,
> Wherein all things created first he weighed,
> The pendulous round Earth with balanced air
> In counterpoise—now ponders all events,
> Battles and realms. In these he put two weights,
> The sequel each of parting and of fight:
> The latter quick up flew, and kicked the beam.
> iv. 996-1004.

The poet's acquaintance with the relative positions of the constellations enabled him to define any particular region in space. For instance, Satan on his return journey to Hell, is described as—

> Betwixt the Centaur and the Scorpion steering
> His zenith, while the Sun in Aries rose.—x. 328-29.

Centaurus and Scorpio are situated on the sphere in proximity to Libra, whose position is directly

[3] The constellation Virgo.

opposite to that of Aries, or at what may be called the other extremity of the celestial equator. Satan, in order to escape the observation of Uriel, Regent of the Sun, kept as far distant as possible from the orb by directing his flight between the two constellations just mentioned.

Milton repeatedly alludes to the constellations, and in so doing enhances the effect of the passages in which they are introduced. In describing the meeting of Michael and Satan on the battlefield, and the commotion caused by their weapons prior to engaging in fight, the poet says:

> Now waved their fiery swords, and in the air
> Made horrid circles; two broad suns their shields
> Blazed opposite, while Expectation stood
> In horror; from each hand with speed retired,
> Where erst was thickest fight, the angelic throng,
> And left large field, unsafe within the wind
> Of such commotion: such as (to set forth
> Great things by small) if, Nature's concord broke,
> Among the constellations war were sprung,
> Two planets, rushing from aspect malign
> Of fiercest opposition, in mid sky
> Should combat, and their jarring spheres confound.
> vi. 304-15.

The return of the Creator to the Heaven of Heavens after the completion of His six days' work was accompanied by universal rejoicing in which the constellations joined:

> Up He rode,
> Followed with acclamation and the sound
> Symphonious of ten thousand harps, that tuned
> Angelic harmonies. The Earth, the Air
> Resounded (thou remember'st, for thou heard'st)

> The heavens and all the constellations rung,
> The planets in their stations listening stood,
> While the bright pomp ascended jubilant.—vii. 557–64.

The angel-quire at the birth of the infant Jesus sung and harped—

> Such music (as 'tis said)
> Before was never made,
> But when of old the Sons of Morning sung,
> While the Creator great
> His constellations set,
> And the well-balanced world on hinges hung:
> And cast the dark foundations deep,
> And bid the weltering waves their oozy channel keep.—II. 117–24.

Adam, on the occasion of his nuptials, says:

> All Heaven,
> And happy constellations, on that hour
> Shed their selectest influence.—viii. 511–13.

Eclipses of the heavenly bodies, whether total or partial, are occurrences which, on account of the phenomena that accompany them, have always been of more than ordinary interest to mankind. An eclipse may be defined as an obscuration of a heavenly body caused by the interposition of another, or by its passage through the shadow of a larger body. An eclipse of the Sun is caused by the passage of the dark body of the Moon between the Earth and the orb. It may be total or partial. An eclipse of the Moon is caused by her passage through the Earth's shadow, and may be total or partial according as she is entirely or partially immersed in it.

When the Moon's apparent diameter exceeds that of the Sun and their centres coincide, a total eclipse

of the Sun occurs. If the Moon's diameter be less, the eclipse is termed 'annular,' because the only visible portion of the Sun appears as a bright ring or annulus round the dark body of the Moon. When their centres do not nearly coincide, a portion only of the Sun's disc is covered; it is then that a partial eclipse occurs.

Milton makes but one allusion to a solar eclipse; it is contained in the famous passage (i. 594–9), in which he describes the Sun as hidden behind the dark body of the Moon, and his light so diminished as to give rise to 'disastrous twilight' in nature.

The occurrence of a total eclipse of the Sun is a most impressive and awe-inspiring spectacle. The gradual effacement of the brilliant orb by the dark body of the Moon; the rapid onset of nocturnal darkness; the visibility of the stars overhead; the lurid aspect of the surrounding landscape; and the profound stillness in animated nature consequent upon the interception of the Sun's light, excite emotions that can be realised only by those who have witnessed the phenomenon.

Milton makes use of the word 'eclipse' when referring to the obscuration of any celestial body or other object when deprived of its light. He alludes to the Moon as undergoing eclipse when affected by the incantations and gruesome rites practised by the night-hag Hecate, and by Lapland witches when indulging in their repugnant calling (ii. 662–6).

The noxious presence of Sin and Death when pursuing their way among the constellations is

indicated by their baneful effect upon the surrounding orbs:

> They with speed
> Their course through thickest constellations held,
> Spreading their bane; the blasted stars looked wan,
> And planets, planet-struck, real eclipse
> Then suffered.—x. 410–14.

One of the adverse changes that occurred in nature after the Fall was:

> air suddenly eclipsed
> After short blush of morn—xi. 183–84.

Samson, in recounting his numerous woes, alludes to his blindness as—

> total eclipse
> Without all hope of day!—S. A. 81–2.

Poets delight in marvels, omens, and portents, and Milton in alluding to eclipses does not fail to refer to the inauspicious forebodings associated with their occurrence. The ill-fated ship that foundered off the Welsh coast in 1637, and with which Edward King—Milton's intimate friend—went down, is referred to by the poet as—

> that fatal and perfidious bark,
> Built in the eclipse, and rigged with curses dark.
> L. 100–1.

In remote ages, long before the dawn of astronomical science, eclipses were regarded by mankind with mingled feelings of terror and dismay. Differing from ordinary phenomena in nature, and ascribed to supernatural agency as manifestations of offended Deity, numerous instances are recorded of the

profound impression made upon men's minds by the occurrence of a total eclipse of the Sun. Herodotus relates how, when a battle was in progress between the Medes and the Lybians, a total solar eclipse occurred which so impressed the combatants that they at once ceased fighting and concluded peace. Plutarch mentions a total eclipse of the Sun that happened about midday. The darkness was so great that it resembled night, and stars were everywhere visible in the sky. The death of the Roman Emperor Domitian was preceded by a portent which was none other than a total solar eclipse.

Did Milton ever witness a total eclipse of the Sun? The reply must be in the negative. For although a partial eclipse is of comparatively frequent occurrence, a total solar eclipse locally visible is exceedingly rare. The celebrated astronomer Halley, when describing a total eclipse of the Sun visible in London on May 3, 1715, remarked that no similar occurrence had been observed in the City since March 20, 1140. In 1652 an eclipse of the Sun occurred that was total over a certain area of the British Isles. Milton at that time resided in London, and was forty-four years of age, but his eyesight, which had been failing for some years previous, became so impaired in the spring of 1652 that total blindness supervened.

The Ecliptic, the name given by astronomers to the great circle which the Sun appears to describe annually in the heavens, was familiarly known to Milton, for the poet was well acquainted with the twelve constellations which the orb traverses. The

Obliquity of the Ecliptic, a term used to indicate the inclination of the ecliptic to the equator, or, in other words, the inclination of the Earth's equator to the plane of her annual path, was also known to him, and when describing the modifications that occurred in the physical universe as a consequence of the first act of transgression, he describes how the poles of the Earth were turned askance twice ten degrees and more from the Sun's axle. The causes upon which depend the sequence of the seasons: the lengthening and shortening of the day; the vernal and autumnal equinoxes; and the summer and winter solstices, were all embraced within the sphere of Milton's knowledge of astronomy.

Besides having been familiar with the 'face of the sky,' Milton was deeply versed in all the astronomical controversies that were being waged in his time, the merits of which he was fully capable of appreciating. The discoveries made by Galileo with the telescope, embracing as they did the spots on the Sun; the lunar mountains and plains; the stellar constitution of the Milky Way; the crescent form of the planet Venus, and the presence of Jupiter's four satellites—to all of which Milton alludes in his poems—testify to the poet's intimate acquaintance with the progressive advancement of the astronomy of his day. All this varied wealth of astronomical allusion and detail Milton linked in poetic sweetness with his lofty muse; accurately described, and admirably expressed in the pages of his 'Paradise Lost.'

CHAPTER IV

MILTON AND GALILEO

MILTON, after his departure from Cambridge, frequently expressed a desire to visit the Continent, where there were many places of interest that he had often longed to see. Having obtained the consent of his kind and indulgent father, he set out on his travels in April 1638 accompanied by a single manservant, and arrived in Paris, where he stayed a few days. During his residence in the French capital, he was introduced by Lord Scudamore, the English ambassador at the Court of Versailles, to Hugo Grotius, one of the most distinguished scholars and philosophic thinkers of his age. From Paris Milton journeyed to Nice, where he first beheld the beauty of Italian scenery and the classic shores of the Mediterranean. From Nice he sailed to Genoa and Leghorn, and after a short sojourn at those places continued his journey inland to Florence, one of the most interesting and picturesque of Italian cities. Situated in the valley of the Arno, and encircled by sloping hills whose sides were studded with residences half hidden among the foliage of gardens and vineyards, Florence, apart

from its natural beauty, was at that time the centre of Italian culture and learning, and the abode of men eminent in literature and science. Here Milton resided for a period of four months, during which time he enjoyed the friendship and hospitality of its most noted citizens, many of whom delighted to honour their English visitor. He was also warmly welcomed by the members of the various literary academies, who admired his conversation and compositions, their flattering encomiums having been amply repaid by him in choice and elegant Latin verse.

During his stay at Florence, Milton visited the illustrious Galileo, who resided at Arcetri, a pleasantly situated suburb that lay just outside the city walls. 'There it was,' he writes, 'I found and visited the famous Galileo, grown old, a prisoner of the Inquisition for thinking in astronomy otherwise than the Franciscan and Dominican licensers thought.' After his abjuration and short imprisonment in 1632, Galileo received permission from the Inquisition to return to his home, but only on condition that he should adhere to certain strict injunctions, which entailed a severe curtailment of his liberty.

Milton does not favour us by mentioning any of the topics that formed the subject of conversation between himself and Galileo, nor does he express any opinion respecting the controversies which at that time agitated both the religious and scientific worlds of thought, and that ultimately culminated in a storm of rancour and hatred which burst over the head of

the aged astronomer and brought him to his knees; yet there can be little doubt but that they were seriously discussed, and that Galileo had in his visitor a sympathetic listener. The telescope, its principle, its mechanism, and methods of observing, were most likely explained to Milton, and we can imagine that he was invited to inspect those in Galileo's observatory and perhaps to test their magnifying power on some object favourably situated for observation. The interesting discoveries made with the instrument without doubt formed a pleasant subject of conversation, and Milton enjoyed the privilege of listening to a detailed description of those from the lips of the blind [1] astronomer. Indeed, it is not improbable that after his visit to Galileo Milton may have appreciated the heliocentric arrangement of our system, for the discoveries made by the 'Tuscan Artist' with his telescope afforded conclusive proof of the truthfulness of the Copernican doctrines.

This memorable interview made a lasting impression upon Milton's mind, and when in years long after, the poet, feeble and blind, began to write his 'Paradise Lost,' the remembrance of Galileo and his telescope still remained vivid and unimpaired.

Galileo was the first astronomer who pointed a telescope to the heavens; and he, besides, deserves the credit of having been the inventor of the instrument which he employed. Although the magnifying

[1] Galileo, at the time of Milton's visit, was totally blind.

power of certain lenses was known from a remote period, it was not until 1608 that the earliest telescope was constructed. The inventor was a Dutchman named Hans Lippershey, who carried on the business of a spectacle-maker in the town of Middelburg. His discovery was purely accidental, and it is said that the instrument, which was directed towards a weather-cock on a church spire—of which it gave a large and inverted image—was for some time exhibited in his shop as a curiosity. The importance of the invention was, however, soon realised, and in the following year telescopes were sold in Paris.

In May 1609, when on a visit to a friend at Venice, Galileo received intelligence of the invention of an instrument by a Dutch optician that possessed the property of causing distant objects to appear much nearer to the observer. Confirmation of this report was afterwards contained in letters which he received from Paris, and this information, Galileo asserted, was all that he had learned about the discovery. Immediately after his return to Padua he applied his abilities to contriving an instrument with properties such as he had heard of, and in the following passage describes the method of reasoning by which he arrived at a successful result. He writes:

> The contrivance consists either of one glass or of more—one is not sufficient, since it must be either convex, concave, or plane. The last does not produce any sensible alteration in objects; the concave diminishes them. It is true that the convex magnifies, but it renders them confused and indistinct; consequently, one glass is insufficient to produce the desired effect. Proceeding to consider two glasses, and bearing in mind that the plane

causes no change, I determined that the instrument could not consist of the combination of a plane glass with either of the *other two*. I therefore applied myself to making experiments of combinations of the other two kinds and thus obtained that of which I was in search.

Galileo's telescope consisted of two lenses--one plano-convex, the other plano-concave—the latter being held to the eye. Those he fixed in a piece of organ-pipe, which served the purpose of a tube—the lenses being distant from each other by the difference of their focal lengths. An opera-glass may be accurately described as a double Galilean telescope. Galileo must be regarded as having been the inventor of this kind of telescope, which in one respect differed very materially from the instrument constructed by the Dutch optician, for, if what has been said about the weather-cock on the church spire be true, then Lippershey's telescope consisted of two convex lenses distant from each other by the sum of their focal lengths, and all objects observed with it appeared inverted. Refracting astronomical telescopes are constructed on this principle as they possess several advantages over the Galilean instrument.

On the completion of his telescope, Galileo returned with it to Venice, where he exhibited it to his friends. The sensation created by this small instrument, which magnified only three diameters, was very extraordinary, and crowds of the principal citizens flocked daily to Galileo's residence in order that they might see the magical tube about which such wonderful reports were being circulated. Galileo next applied

his mechanical skill to making instruments of larger size, and 'at length,' he writes, 'sparing neither labour nor expense,' constructed a telescope so excellent as to be capable of magnifying more than thirty times. He now commenced an exploration of the celestial regions, and on carefully examining some of the heavenly bodies with his glass made many wonderful discoveries that greatly enhanced his reputation as an astronomer, and added fame and lustre to his name.

The first celestial object to which Galileo directed his telescope was the Moon, which, he remarked, appeared so near as if it were distant only two semi-diameters of the Earth. He was deeply interested to find how closely her surface resembled that of our globe; and was able to detect on almost every part of the lunar disc lofty mountain ranges, vast plains, deep valleys, and elevated ridges and depressions similar to those that exist on the Earth. The dark and luminous portions of her surface, Galileo surmised, indicated the existence of continents and seas that reflected with unequal intensity the light of the Sun.

Galileo's opponents and the followers of Aristotle received the announcement of these discoveries with much displeasure. They maintained that the Moon was perfectly spherical, and absolutely smooth—a vast mirror, the darkened portions of which were the reflection of our terrestrial mountains and forests—and accused Galileo of 'taking a delight in distorting and ruining the fairest works of nature.' Galileo appealed to the evidence of his observations, and to

the unevenness of our globe. In his opinion the Moon's irregular surface was a proof of Divine wisdom; and had it been absolutely smooth the orb would have been 'but a vast and unblessed desert, void of animals, of plants, of cities and men—senseless, lifeless, soulless, and stripped of all those ornaments which now render it so variable and so beautiful.' Galileo's arguments were, however, of little avail in altering his opponents' preconceived notions of the lunar disc.

Evidence of the deep and lasting impression made upon Milton's mind by his visit to Galileo is apparent in the 'Paradise Lost,' which contains repeated allusions to the discoveries made by the Florentine astronomer with his telescope. The first of these applies to the Moon. In his description of the massive shield carried by Satan, the poet says:

> His ponderous shield,
> Ethereal temper, massy, large, and round,
> Behind him cast. The broad circumference
> Hung on his shoulders like the Moon, whose orb
> Through optic glass the Tuscan artist views
> At evening, from the top of Fesolé,
> Or in Valdarno, to descry new lands,
> Rivers or mountains, in her spotty globe.—i. 284–91.

The Tuscan artist is Galileo, who was a native of the State of Tuscany, of which Florence is the capital. In describing Galileo as observing the Moon from the top of Fesolé, a hill distant about three miles from the city, or in Valdarno—the valley of the Arno—Milton is recalling happy memories of his stay at Florence, where he occupied his time in taking pleasant

walks perhaps—sometimes by moonlight—into the suburbs and surrounding country. It was when on one of these rambles that he 'found' and 'visited' Galileo, who occupied a picturesque villa that stood on the left bank of the Arno.

Galileo firmly believed in the habitability of the Moon, and Milton appears to have entertained a similar opinion with respect to the orb. The poet surmises the existence of new lands, rivers, or mountains, on the lunar surface—discoveries made by Galileo. The term 'spotty globe' is more applicable to our satellite when viewed through the telescope than when seen with the naked eye. Galileo's attention was attracted by the freckled aspect of the Moon—a visual effect created by the numerous extinct volcanoes that abound on the surface of the orb.

Milton again mentions the Moon when referring to Galileo and his telescope—

> as when by night the glass
> Of Galileo, less assured, observes
> Imagined lands and regions in the Moon.
> v. 261–63.

The archangel Raphael in his flight through space views from afar the inequalities of the Earth's surface, which resemble in appearance the imagined lands and regions discovered by Galileo's glass on the lunar disc. Milton had probably in remembrance the indistinct and ill-defined aspect presented by objects when observed from a great distance.

Although Milton regarded the Moon as a habitable world, he does not assert that the orb is the abode of

life, but considers it as highly probable. In localising the Limbo of Vanity the poet says:

> Not in the neighbouring Moon as some have dreamed;
> Those argent-fields more likely habitants,
> Translated Saints, or middle Spirits, hold,
> Betwixt the angelical and human kind.—iii. 459-62.

Here we have an instance of the poet's love of the medieval and ancient when he refers to the Moon as being most likely inhabited by semi-angelical beings.

In the quaint philosophy propounded by Raphael when conversing with Adam in Paradise, the angel delivers himself thus:

> For know, whatever was created, needs
> To be sustained and fed; of elements
> The grosser feeds the purer: Earth the Sea;
> Earth and the Sea feed Air: the Air those Fires
> Ethereal, and, as lowest, first the Moon;
> Whence in her visage round those spots, unpurged
> Vapours not yet into her substance turned.
> Nor doth the Moon no nourishment exhale
> From her moist continent to higher orbs.
> The Sun, that light imparts to all, receives
> From all his alimental recompense
> In humid exhalations, and at even
> Sups with the ocean.—v. 415-26.

According to this strange physical system which was upheld by the ancients, vapours or exhalations emitted by the lower orbs were absorbed by the higher, which they maintained and nourished. Pliny imagined the spots on the Moon were humours or vapours exhaled by the Earth, which, having reached our satellite, were not yet absorbed into her substance.

It is singular that Milton should have ascribed such philosophy to an archangel, but science is unable to affirm or deny the assumption that the Sun and stars receive alimental nourishment. This speculative theory has attracted many minds, and Milton, who was deeply versed in ancient philosophy, exhibits his partiality for classical tradition by introducing it in his poem. It may be unphilosophical to say that the Sun 'sups with the ocean,' but it is not unpoetical.

In describing phenomena on the Moon similar to what are experienced on Earth, Milton prefaces his utterance with the remark:

> if land be there,
> Fields and inhabitants? Her spots thou seest
> As clouds, and clouds may rain, and rain produce
> Fruits in her softened soil, for some to eat
> Allotted there.—viii. 144–48.

The poet does not say that the darkened portions of the lunar surface are clouds, but surmises the existence of aqueous vapour on the Moon, and consequently the presence of animal and vegetable life. If the lunar spots were obscurations caused by the presence of clouds they would constantly vary in form and size, and occasionally disappear. But the naked-eye appearance of the Moon never varies, and of this Milton must have been perfectly well aware.

Galileo regarded the Moon as a duplicate of her primary—a world teeming with life. But Milton exercises greater caution when referring to the orb. Apparently he seems to favour the assumption that

the lunar surface is capable of sustaining life, and that there are inhabitants on the Moon—a conclusion commonly upheld in his day. But his belief does not reach beyond the possibility of such a condition of things, and further he does not venture. The poetic licence indulged in by Milton when dealing with lunar affairs is not greater than what might be reasonably claimed on his behalf.

The discovery of Jupiter's four moons—to which Milton alludes indirectly—was one of Galileo's most brilliant achievements with the telescope. On the night of January 7, 1610, when engaged in observing Jupiter with his glass, Galileo perceived three small stars in proximity to the planet. They appeared brighter than adjacent stars of the same magnitude, and two were to the east and one to the west of the orb. The three were in a straight line and parallel to the ecliptic. Believing they were fixed stars, Galileo paid them no special attention. On the following night, when observing with his telescope, he was surprised to find all three stars to the west of Jupiter and nearer to each other. This occasioned him considerable surprise, and he was puzzled to know how the planet could be east of the three stars when on the preceding night he was to the west of two of them. The only explanation he could give was that Jupiter's motion was contrary to astronomical calculations, and that he had got in advance of the other stars. Galileo's next opportunity of observing them was on the 10th, when two only of the stars were visible and they both were to the east of the

planet. As it was obviously impossible that Jupiter could have travelled from west to east on January 8, and from east to west on the 10th, Galileo concluded that the observed phenomenon arose from the motion of the stars. He now applied himself assiduously to watching the stars on successive evenings and discovered a fourth, and on perceiving how they changed their positions relatively to each other, and to Jupiter, he arrived at the conclusion that the stars were four moons which revolved round Jupiter in the same manner as the moon revolves round the Earth.

The announcement of the discovery of Jupiter's four satellites created a profound impression, and its significance became at once apparent. The followers of Ptolemy and of Aristotle received the information with much displeasure and incredulity, and positively refused to believe Galileo, whom they accused of inventing fables. On the other hand, the upholders of the Copernican system hailed the announcement with satisfaction, as it declared that Jupiter with his four moons constituted a system of greater magnitude and importance than that of our Earth with her single satellite, which therefore could not be regarded as the centre of the Universe.

Kepler, on hearing of Galileo's discovery of the four moons of Jupiter, sent him the following characteristic letter:

I was sitting idle at home thinking of you most excellent Galileo and your letters, when the news was brought me of the discovery of four planets by the help of the double eye-glass . . .

I am so far from disbelieving in the existence of the four circumjovial planets that I long for a telescope to anticipate you in discovering two round Mars (as the proportion seems to me to require), six or eight round Saturn, and perhaps one each round Mercury and Venus.

Intelligence of Galileo's discovery was received by his opponents in a spirit entirely different from that manifested by Kepler. The principal professor of philosophy at Padua, when requested to look at the Moon and planets through Galileo's glass, persistently declined, and did his utmost to persuade the Grand Duke of Tuscany that the Jovian satellites could not possibly exist.

Evidence in support of the presence of Jupiter's moons became so conclusive that Galileo's opponents were compelled to renounce their disbelief in them, whether real or pretended. The Grand Duke, preferring to trust his eyes rather than rely upon the arguments of the professor at Padua, observed the satellites on several occasions with Galileo, and as a mark of appreciation of his discovery presented him with a handsome gift.

Several of Galileo's opponents now declared that his discovery was incomplete, and that Jupiter had more than four satellites in attendance upon him. Scheiner counted five, Rheita nine, and other observers increased the number to twelve. But it was found to be quite as hazardous to exceed the number stated by Galileo as it was to deny the existence of any, for when Jupiter had traversed a short distance of his path among the fixed stars, the only bodies that accompanied him were his four

original attendants, which continued to revolve round him with unerring regularity in every part of his orbit.

Jupiter, the giant planet of our system—the orb has a mean diameter of 88,000 miles—must have been a familiar object to Milton, for when nearest to the Earth his brilliancy rivals that of Venus. The poet's cognisance that Galileo was the discoverer of the planet's four moons must have also enhanced his interest in the orb.

In the following lines there is a pointed allusion to the Jovian satellites:

> and other suns, perhaps,
> With their attendant moons,[2] thou wilt descry,
> Communicating male and female[3] light.—viii. 148-50.

Milton, in indicating the existence of other planets makes use of the expression, 'other suns'; this need occasion no surprise, for in the poet's time astronomical phraseology was given a wide latitude. Galileo describes his Jovian satellites as 'planets.' He writes, 'and these new planets move round a very great star in the same way as Venus and Mercury, and peradventure the *other known planets move round* the Sun.' Milton may have conceived the happy idea that Jupiter, in his relation to the moons that circle round him, exercises functions similar to those which it is the Sun's prerogative to fulfil. Indeed, the Jovian system may well be regarded as a

[2] Some of Milton's commentators credit Galileo with the discovery of 'Jupiter and of Saturn's satellites,' but none of the latter's moons were discovered in Galileo's lifetime.

[3] Direct and reflected light.

miniature solar system, for recent discoveries have added four more gems to the diadem of Jupiter.

In the year 1610, Galileo, on directing his telescope to the Sun, discovered dark spots on the surface of the orb. Similar spots sufficiently large to be distinguished by the naked eye were observed from time to time for centuries prior to the invention of the telescope, but they attracted scant attention, and no surmises were hazarded as to their nature and origin. Galileo was much puzzled in accounting for the spots. He at first concluded that the Sun either rotated on his axis, or that planets like Mercury and Venus revolved in such close proximity to the orb that in crossing his disc they appeared as dark spots. After further observation he ascertained that the spots were in actual contact with the Sun; that they were of irregular form; that sometimes a spot divided into three or four smaller spots, and that occasionally several united to form a single spot. Galileo eventually arrived at the conclusion that the spots were clouds which floated in the solar atmosphere, and that they intercepted a portion of the Sun's light. He observed that they all possessed a common proper motion, and appeared to rotate with the orb; and judging by the time they occupied in crossing the solar disc he inferred that the Sun rotates on his axis in about twenty-eight days—a near approach to the truth.

In describing Satan's environment after having landed in the Sun, Milton again refers to Galileo and his telescope, for the poet was aware that the solar

disc was one of the objects subjected to the scrutiny of the instrument:

> There lands the Fiend, a spot like which perhaps
> Astronomer in the Sun's lucent orb
> Through his glazed optic tube yet never saw.
> iii. 588-90.

No astronomer with his glass ever beheld such brightness as Satan perceived when in the midst of the solar radiance.

The Milky Way, known also as the Galaxy, was one of the celestial objects that attracted Galileo's attention. On directing his telescope to this luminous tract he discovered, to his inexpressible delight, that it consisted of multitudes of stars so remote as to be incapable of definition by the naked eye; and that its cloudy luminosity was an effect created by the blended light of myriads of stars still more distant which his telescope was unable to resolve. In his *Nuncius Sidereus* Galileo gives an account of his observations of the Galaxy, and expresses his satisfaction with having been able to terminate an ancient controversy by demonstrating to the senses the stellar structure of the Milky Way.

Milton alludes but once to the Milky Way (vii. 574-81) and his sublime description of this luminous zone is based upon Galileo's discovery of its stellar constitution.

Galileo did not afford his opponents much time to deny or controvert with argument his telescopic discoveries before the announcement of a new one diverted public attention from those already made

known. He, however, exercised greater caution in disclosing the results of his observations, as other persons laid claim to having made the same discoveries prior to the time that his were announced. Galileo therefore adopted a method in common use among astronomers in those days by means of which they announced a discovery by transposing the letters in a sentence so as to form an anagram. The anagram that concealed Galileo's next discovery was as follows:

> Haec immatura a me jam frustra leguntur oy.

This when deciphered reads

> Cynthiae figuras aemulatur mater amorum.
> (Venus rivals the appearances of the Moon.)

It was in this manner that Galileo announced his discovery of the phases of Venus, the peerless planet of our morning and evening skies, whose slender crescent forms such a beautiful object in the telescope, and who, as she traverses her orbit, exhibits all the varied changes of form presented by the Moon on her monthly journey round the Earth. These recurring phases of Venus, from slender crescent to full moon, afforded Galileo irresistible proof that the planet was an opaque body which derived its light from the Sun when circling round the orb convincing evidence of the accuracy and truthfulness of the Copernican hypothesis.

These varying aspects of Venus were not unknown to Milton, nor has he failed to introduce in his poem an allusion to this beautiful phenomenon. Having

mentioned in their order the creation of the heavenly bodies, and after the Sun became a radiant orb of light, the poet adds:

> Hither, as to their fountain, other stars
> Repairing, in their golden urns draw light,
> And hence the morning planet gilds her horns.
>
> vii. 364–66.

In 'Paradise Regained' (iv. 40–2) the telescope is mentioned by that name.

Perhaps no event in Milton's lifetime afforded him greater pleasure than his visit to the Continent. In several of his letters he expresses in ardent language the intense and unalloyed delight which he experienced when making a tour of the cities of Italy. Among them, Florence and its environs engaged a large share of his affections; the hills of Fesolé, and the stream of the Arno were often visited by him during his prolonged stay in the city, which 'he loved for its language, its genius, and its taste.' With such happy memories, it would seem only natural that Milton should have introduced in his poems numerous incidents commemorative of the joyous days when he roamed over Italy. They are, however, few in number, and except for an allusion to the innumerable fallen leaves in Vallombrosa—the shady valley—his thoughts appear to have reverted mainly to Galileo and his telescope. Milton's repeated allusions to the Florentine astronomer, whose career was so full of dramatic interest, whilst adding charm and variety to certain passages in his great epic, enabled him also to introduce with increased attractiveness

similes suggested by the telescopic appearance of certain celestial objects. For instance, the passage in which Satan's shield is compared to the full-orbed moon is much enhanced by the accompanying reference to the 'Tuscan artist' and his telescope. Likewise, when Raphael in his flight through space approached the Earth, he beheld from afar the inequalities of her surface, mountains, valleys, and plains, such as Galileo imagined he saw through his glass on the Moon. In describing the landing of Satan in the Sun the poet introduces the 'glazed optic tube' through which Galileo scanned the orb.

Milton does not allude to Galileo's blindness, which was total at the time of his visit to the aged astronomer. He mentions the names of blind Thamyras, of blind Mæonides (Homer), of Tiresias and Phineus, blind prophets of ancient fame, and pathetically alludes to his own affliction. But, notwithstanding this omission on the part of our great English poet, he fully appreciated the ardour and originality of Galileo's genius, nor has he failed to include him among the renowned few whose names are immortalised in the pages of his 'Paradise Lost.'

CHAPTER V

THE SEASONS

THE great path of the Sun among the constellations as seen from the Earth is called the Ecliptic. It is divided into 360°, and again into twelve equal parts of 30° called *signs*. The ecliptic intersects the celestial equator at two points called the *equinoxes*, and is inclined thereto at an angle of very nearly $23\frac{1}{2}°$, which is the measure of the inclination of the Earth's axis to that of her orbit or the ecliptic, and is termed by astronomers the *obliquity of the ecliptic*. Milton alludes to the ecliptic when describing Satan's precipitate journey from the Sun to Earth:

> Down from the ecliptic, sped with hoped success,
> Throws his steep flight in many an airy wheel,
> Nor staid, till on Niphate's top he lights.
>
> iii. 740 12.

Extending for 9° on each side of the ecliptic is a zone or belt called the Zodiac, and within this space the principal planets perform their annual revolutions. It was at one time believed that the paths of all the planets lay within the zodiac, but on the discovery of the minor planets, Aries, Pallas,

and Juno, it was ascertained that they travelled beyond this zone. The zodiac is of great antiquity; it was known to the ancient Egyptians, Chaldeans, and Hindus, and is mentioned in the earliest astronomical records. The stars comprised within the zodiac are divided into twelve groups or constellations, which correspond with the twelve 'signs,' and are each named after some animal or object which the configuration is supposed to resemble. The twelve zodiacal constellations are named as follows:

Aries, the Ram	Libra, the Balance
Taurus, the Bull	Scorpio, the Scorpion
Gemini, the Twins	Sagittarius, the Archer
Cancer, the Crab	Capricornus, the Goat
Leo, the Lion	Aquarius, the Water-bearer
Virgo, the Virgin	Pisces, the Fishes

In close association with the Earth's annual journey round the Sun, are the Seasons, upon the regular sequence of which mankind depend for the various products of the soil essential for the maintenance and enjoyment of life. The revolution of the Earth in her orbit, and the inclination of her axis to her annual path causing the plane of the equator to be inclined $23\frac{1}{2}^\circ$ to that of the ecliptic, are the reasons which account for the succession of the seasons—Spring, Summer, Autumn and Winter. In consequence of the obliquity of the ecliptic, the Sun appears to travel $23\frac{1}{2}^\circ$ north and $23\frac{1}{2}^\circ$ south of the equator. When the orb attains his highest northern altitude which is on June 21, we have the summer solstice, and the longest days: when, by retracing his

steps he declines $23\frac{1}{2}°$ south of the equator, at which point he arrives on December 21, we have the winter solstice and the shortest days. Intermediate between these two seasons are spring and autumn. When the Sun on his journey northward from his lowest point of declination reaches the equator on March 21, we have the vernal equinox, and at this period of the year the days and nights are of equal length all over the world. Again when the orb on his downward journey reaches the equator on September 21, the autumnal equinox occurs. In summer the north pole is inclined towards the Sun, consequently his rays fall more direct and impart much more heat to the northern hemisphere than in winter, when the pole is turned away from the Sun. This difference in the incidence of the solar rays upon the surface of the globe, along with the increased length of the day, mainly accounts for the high temperature of summer as compared with that of winter.

Astronomically the seasons commence at the periods of the equinoxes and solstices. Spring begins on March 21, when the vernal equinox occurs; summer on June 21 at the summer solstice; autumn on September 21 when the autumnal equinox occurs; and winter on December 21 at the winter solstice. These conventional divisions of the year do not apply equally to all parts of the globe. In the arctic and antarctic regions, spring and autumn are very brief, summer is short, and the winter of long duration. In the tropics, owing to the comparatively slight difference in the obliquity of the solar rays, one season

as regards warmth is not much different from the other, but in the temperate regions of the Earth the vicissitudes of the seasons are more perceptible, and can be most readily recognised by the changes that occur in the foliage of shrubs and trees. In spring there is the budding; in summer the blossoming; in autumn the fruit-bearing; in winter the leafless condition of deciduous trees, and the repose of vegetable life.

In describing the loveliness of Paradise, Milton introduces the legendary belief that before the Fall there reigned on the Earth a perpetual Spring:

> Thus was this place,
> A happy rural seat of various view:
> Groves whose rich trees wept odorous gums and balm;
> Others whose fruit, burnished with golden rind,
> Hung amiable—Hesperian fables true,
> If true here only—and of delicious taste.
> Betwixt them lawns, or level downs, and flocks
> Grazing the tender herb, were interposed,
> Or palmy hillock; or the flowery lap
> Of some irriguous valley spread her store,
> Flowers of all hue, and without thorn the rose.
> Another side, umbrageous grots and caves
> Of cool recess, o'er which the mantling vine
> Lays forth her purple grape, and gently creeps
> Luxuriant; meanwhile murmuring waters fall
> Down the slope hills dispersed, or in a lake,
> That to the fringèd bank with myrtle crowned
> Her crystal mirror holds, unite their streams.
> The birds their quire apply; airs, vernal airs,
> Breathing the smell of field and grove, attune
> The trembling leaves, while universal Pan,
> Knit with the Graces and the Hours in dance,
> Led on the eternal Spring. iv. 246-68.

These scenes of tranquil bliss were, however, of

transient duration, for after the commission of the *first act of transgression by our grandparents*—

> Nature from her seat,
> Sighing through all her works, gave signs of woe
> That all was lost.—ix. 782 84.

As evidence of the Divine displeasure, the Creator instructed His mighty angels to disturb the harmony of the elements, and to bring about those adverse physical changes in nature that supervened after the Fall. Extremes of heat and cold, unpleasant to endure, began to affect the Earth, and blustering winds, and storms accompanied by the terrifying roll of thunder raged on land and sea. The heavenly bodies with inauspicious aspects contributed to the general confusion. The pale Moon and the planets were given power to combine with noxious effect, and the fixed stars to shed their malignant influences:

> The Sun
> Had first his precept so to move, so shine,
> As might affect the Earth with cold and heat
> Scarce tolerable, and from the north to call
> Decrepit winter, from the south to bring
> Solstitial summer's heat. To the blanc Moon
> Her office they prescribed; to the other five
> Their planetary motions and aspects,
> In sextile, square, and trine, and opposite,
> Of noxious efficacy, and when to join
> In synod unbenign; and taught the fixed
> Their influence malignant when to shower;
> Which of them rising with the Sun, or falling,
> Should prove tempestuous. To the winds they set
> Their corners, when with bluster to confound
> Sea, air, and shore; the thunder when to roll
> With terror through the dark aerial hall.—x. 651-67.

Milton's familiarity with astrological terms and phrases justifies us in concluding that he possessed more than a superficial knowledge of this occult science. In the seventeenth century many persons believed in astrology, and in the influence exerted by the heavenly bodies over human and mundane affairs. Professors of this art were, in those days, actively engaged in 'casting nativities,' and in predicting terrestrial occurrences by making observations of the celestial orbs. Although now regarded as a superstition, astrology possessed a fascination for great and solitary minds, and men of high attainments were firm believers in this mystical science.

In accounting for these adverse physical changes in nature, Milton makes use of his astronomical knowledge by suggesting two hypotheses: (1) An alteration in the inclination of the Earth's axis; (2) A deviation of the Sun's path from the equinoctial road. Both are consistent with the Ptolemaic theory.

> Some say he bid his Angels turn askance
> The poles of Earth twice ten degrees and more
> From the Sun's axle; they with labour pushed
> Oblique the centric globe: some say the Sun
> Was bid turn reins from the equinoctial road
> Like distant breadth to Taurus with the seven
> Atlantic Sisters, and the Spartan Twins,
> Up to the Tropic Crab; thence down amain
> By Leo and the Virgin and the Scales,
> As deep as Capricorn; to bring in change
> Of seasons to each clime; else had the spring
> Perpetual smiled on Earth with vernant flowers.
> x. 668-79.

Milton assumes that before the Fall, the axis of the stationary Earth was directed at right angles to what is now known as her annual path, and that the plane of the ecliptic coincided with that of the equator. Consequently, the Sun's path continued permanently on the equator where his rays were vertical, and north and south of this line each locality on the Earth enjoyed one constant season, the distinctive qualities of which depended upon its geographical position. In what are called the temperate regions of the globe there existed one perpetual season similar, both as regards climate and length of day, to what is experienced at the equinoxes when the Sun is for a short period on the equator. There were then no extremes of heat and cold, no winter, and no summer, no lengthening and shortening of the day, so that an entirely different order of things prevailed from what is now experienced on Earth. But by the displacement of the Earth's axis 'twice ten degrees and more from the Sun's axle' the plane of the equator was inclined at an angle of $23\frac{1}{2}°$ to that of the ecliptic—a modification of the physical universe which the poet says was for the worse, and which accounted for the undesirable and unpleasant changes that occurred in nature after the first act of transgression. The tilting of the Earth's axis is described by Milton as having been accomplished by the might of angels, who, 'with labour pushed oblique the centric globe.'

The second reason assigned by the poet, viz. the deviation of the Sun's path from the equinoctial road

to that which he now pursues, would also account for the disagreeable changes referred to. Instead of circling continuously round the Earth's equator, the orb had his course so altered as to travel a distance of $23\frac{1}{2}°$ north and $23\frac{1}{2}°$ south of this line. Milton describes the Sun's path with marked precision. The orb on his northern journey from the equator passes through Taurus with the seven '*Atlantic Sisters*'—the Pleiades; then through Gemini containing the 'Spartan Twins'—Castor and Pollux; and enters the sign Cancer—the 'Tropic Crab' on June 21 when he attains his highest northern altitude at the summer solstice. Then having passed through Cancer in his descent, he traverses Leo and Virgo, and on September 23 enters Libra (the Scales) when he is again on the equator. Continuing his downward journey he enters Capricornus on December 21, and thus reaches his lowest point of declination at the winter solstice, again to renew his ascent. It is this apparent upward and downward motion of the Sun from the equator that brings about the rise and fall of temperature, and the difference in the length of the day peculiar to each season of the year.

The happy idea expressed by Milton that the primitive Earth enjoyed a perpetual spring, although pleasing to the imagination, and well adapted for poetic description, is not sustained by any astronomical testimony. Indeed, the position of the Earth having her axis at right angles to her *orbit* is one which may be regarded as being ill-adapted for the support and maintenance of life upon her surface, just as her

present position is the best that can be imagined for fulfilling this purpose. Astronomy teaches us to rely with certainty upon the permanence and regular sequence of the seasons. The position of the Earth's axis as she speeds along in her orbit through the unresisting ether remains unchanged, and her rapid rotation has the effect of increasing its stability. Yet, the Earth accomplishes none of her motions with rigid precision, and there is occurring a very slow alteration in the inclination of her axis which if unchecked will eventually produce a coincidence of the equator and the ecliptic. Instead of a succession of the seasons, the inhabitants of the Earth would enjoy a perpetual spring; and although the lapse of a great epoch of time would be required to bring about such a change, there would ultimately occur a condition of things entirely different from what is now experienced. But, before the ecliptic can have approached the equator to a degree sufficient to produce any sensible alteration in the climate of the Earth, its motion in that direction must cease, and after becoming stationary for a time it will begin to recede towards its former position. The seasons must therefore succeed each other through all time, reminding us of the promise of the Creator, that 'while the earth remaineth, seed-time and harvest, and cold and heat, and summer and winter, shall not cease.'

The beautiful seasons, which impart such charm and variety to the rolling year, have in every age commanded the admiration of poets and of all lovers

of nature who delight in the pleasing vicissitudes visible in Earth and sky that accompany each. Spring, with her verdant fields and flowery meads. Summer, decked in her pride of bloom and radiant sunshine. Autumn, rich with her gathered wealth of golden store; and icy Winter, mantled in robe of snowy white, have each had *their charms and* attractive aspects portrayed by Milton in numbers that testify to their power of exciting his poetic fancy, and of stimulating the flow of his captivating muse.

Milton associates joyousness and hilarity with the Spring that—

> to the heart inspires
> Vernal delight and joy, able to drive
> All sadness but despair —iv. 154–56.

In 'L'Allegro' he alludes to—

> The frolic wind that breathes the spring.—L'A. 18.

and in 'Comus' the Spirit in his epilogue says:

> Along the crispèd shades and bowers
> Revels the spruce and jocund Spring;
> The Graces and the rosy bosomed Hours,
> Thither all their bounties bring.
> There eternal Summer dwells,
> And west winds with musky wing
> About the cedarn alleys fling
> Nard and cassia's balmy smells.—C. 984–91.

The awakening of the insect world to life, a consequence due to the increased warmth of the Sun's rays, is happily described in the following citation:

As bees
In spring-time, when the Sun with Taurus rides,
Pour forth their populous youth about the hive
In clusters; they among fresh dews and flowers
Fly to and fro, or on the smoothèd plank,
The suburb of their straw-built citadel,
New rubbed with balm, expatiate, and confer
Their state affairs.—i. 768-75.

The Sun enters Taurus about April 20, and when traversing this sign the vivifying effect of the solar heat and light becomes apparent in the rapid growth of foliage, in the appearance of insects, and in the general renewal of life everywhere visible in nature.

Samson describes his anguish and mental torture as such:

which no cooling herb
Or medicinal liquor can assuage,
Nor breath of vernal air from snowy Alp.
S. A. 626-28.

Manoah, on hearing of the death of Samson, alludes to the vain hope he cherished of his son's release as being –

Abortive as the first-born bloom of spring
Nipt with the lagging rear of winter's frost!
S. A. 1576-77.

In a sonnet composed on reaching his twenty-third birthday, Milton says of himself:

My hastening days fly on with full career,
But my late spring no bud or blossom sheweth.—S. 3-4.

The poet's delight in the ever-changing aspect of Earth and Sky; in the varied beauty of light and shade, of sunshine and shower, is felicitously expressed in the following passage:

As when from mountain-tops the dusky clouds
Ascending, while the north wind sleeps, o'erspread
Heaven's cheerful face, the lowering element
Scowls o'er the darkened landskip snow or shower;
If chance the radiant Sun with farewell sweet
Extend his evening beam, the fields revive,
The birds their notes renew, and bleating herds
Attest their joy, that hill and valley rings.—ii. 488-95.

. Milton's appreciation of vernal delights; of 'meadows trim with daisies pied'; of low secluded valleys decked with flowers of mingled hue; of the murmur of rippling brooks, and the whisper of soft winds, finds charming expression in his lament over the fate of Lycidas:

Return, Alpheus, the dread voice is past,
That shrunk thy streams; return Sicilian Muse,
And call the vales, and bid them hither cast
Their bells, and flowerets of a thousand hues.
Ye valleys low, where the mild whispers use
Of shades, and wanton winds, and gushing brooks,
On whose fresh lap the swart star sparely looks,
Throw hither all your quaint enamelled eyes,
That on the green turf suck the honied showers,
And purple all the ground with vernal flowers.
Bring the rathe primrose that forsaken dies,
The tufted crow-toe, and pale jessamine,
The white pink, and the pansy freaked with jet,
The glowing violet,
The musk rose, and the well-attired woodbine,
With cowslips wan that hang the pensive head,
And every flower that sad embroidery wears;
Bid amaranthus all his beauty shed,
And daffodillies fill their cups with tears,
To strew the laureate hearse where Lycid lies.
L. 132-51.

We learn on the authority of his nephew, Edward Phillips, that the flow of Milton's muse was influenced

by the seasons, and that the period of the year in which Nature dons her loveliest garb was not the time when he was happiest in the composition of his verse. Having been asked the reason why he left off composing in the summer, Milton replied, that 'his vein never happily flowed but from the autumnal equinox to the vernal, and that whatever he attempted [at other times] was never to his satisfaction though he courted his fancy never so much.'

With Summer, Milton associates sunshine and flowers; solstitial heat with cool interposition of umbrageous shade, and all the delights of morning, noontide, and evening, that mark the phases of a summer's day.

The urban dweller in quest of rural pleasures is described as—

> Forth issuing on a summer's morn to breathe
> Among the pleasant villages and farms
> Adjoined, from each thing met conceives delight—
> The smell of grain, or tedded grass, or kine,
> Or dairy, each rural sight, each rural sound.
> ix. 447-51.

The poet associates the nightingale's song with summer:

> Where the Attic bird
> Trills her thick warbled notes the summer long.
> P. R. iv. 246.

In the list of heathen deities enumerated by Milton, he says:

> Thammuz came next behind,
> Whose annual wound in Lebanon allured
> The Syrian damsels to lament his fate
> In amorous ditties all a summer's day.—i. 446-49.

Of Beelzebub, when about to address the Stygian Council, the poet remarks:

His look
Drew audience and attention still as night
Or summer's noontide air, while thus he spake.
ii. 307–9.

The revels, masques, and stately pageantries that were in vogue at one time as a source of amusement, resembled—

Such sights as youthful poets dream
On summer eves by haunted stream.
L'A. 129–30.

In describing the genesis of insects, Milton compares their gorgeous colours to the bloom of summer:

Those waved their limber fans
For wings, and smallest lineaments exact
In all the liveries decked of summer's pride.
vii. 476–78.

In endeavouring to comfort Samson, Chorus adds:

Nor do I name of men the common rout,
That, wandering loose about,
Grow up and perish as the summer fly.
S. A. 674–76.

In his pathetic allusion to his blindness, Milton recalls delightful memories associated with the seasons:

Thus with the year
Seasons return; but not to me returns
Day, or the sweet approach of even or morn,
Or sight of vernal bloom, or summer's rose,
Or flocks, or herds, or human face divine
iii. 40–4.

The gradual fading of summer hues to russet-gold and brown; the pleasing aspect of waving

fields of ripened grain, and of trees richly laden with fairest fruit, proclaim the presence of autumn; and that Earth having yielded her increase, will seek a long repose ere she awakens again to renewed life.

In describing the repast which the angel Raphael shared with Adam and Eve in Paradise, the poet says:

> Raised of grassy turf
> Their table was, and mossy seats had round,
> And on her ample square from side to side
> All autumn piled, though spring and autumn here
> Danced hand-in-hand.—v. 391–95.

Milton compares the number of fallen angels that lay on the burning lake to autumn leaves:

> Angel forms, who lay entranced,
> Thick as autumnal leaves that strow the brooks
> In Vallombrosa.—i. 301–3.

The frequency with which falling stars are seen in the autumn, especially about the middle of August when the Perseid meteors make their appearance, did not escape Milton's observation. In proof of this he alludes to Ariel's flight being 'swift as a shooting star in autumn'—and also to the angelic prediction that Satan's fall from Heaven shall be—

> like an autumnal star,
> Or lightning.—P. R. iv. 619–20.

With the advent of winter we arrive at that period of the year when the Sun, having reached his lowest point of declination, sends us the minimum quantity of light and heat. In consequence of this diminution of the solar effluence, many important

changes occur in both the animal and vegetable kingdoms. The migration of birds; the disappearance of insect life; the hibernation of certain animals; the naked condition of deciduous trees; the ice-bound rivers, and snow-clad mountains and plains, testify to the dependence of every living thing upon light and heat, of which the Sun is the prime source.

Milton commences his 'Hymn on the Nativity' with an allusion to winter, and compares the snowy covering of the landscape to a mantle which conceals the repulsiveness of impurity and sin:

I

It was the winter wild,
While the Heaven-born child
All meanly wrapt in the rude manger lies;
Nature, in awe to Him,
Had doffed her gaudy trim,
With her great Master so to sympathise:
It was no season then for her
To wanton with the Sun, her lusty paramour.

II

Only with speeches fair
She woos the gentle air
To hide her guilty front with innocent snow,
And on her naked shame,
Pollute with sinful blame,
The saintly veil of maiden white to throw;
Confounded that her Maker's eyes
Should look so near upon her foul deformities

The poet alludes to the warmth from burning faggots as a protection—

Against a winter's day when winds blow keen.
P. R. i. 317.

Milton introduces in the 'Passion,' the winter solstice (December 21), when the days are shortest, and the light soon fades:

> But headlong joy is ever on the wing,
> In wintry solstice like the shortened light
> Soon swallowed up in dark and long outliving night.
> P. 5-7.

Winter is often associated with death, and Milton, in his poem 'On the Death of a Fair Infant,' expresses his thoughts in harmony with this sentiment:

> O fairest flower, no sooner blown but blasted,
> Soft silken primrose fading timelessly.
> Summer's chief honour, if thou hadst outlasted
> Bleak Winter's force that made thy blossom dry;
> For he, being amorous on that lovely dye
> That did thy cheek envermeil, thought to kiss,
> But killed, alas! and then bewailed his fatal bliss.
> D. F. I. 1 7.

These numerous quotations enable us to perceive with what delight Milton hailed the beautiful seasons. They also testify to the ardour of his poetic genius that luxuriated in the ever-changing aspects of Nature that from day to day met his observant gaze; and although overtaken by blindness when he sat down to compose his immortal epic, yet, those glad remembrances remained as fresh and green in his memory as when in his youth he roamed among the pleasant fields and winding lanes of Buckinghamshire.

CHAPTER VI

SUN, MOON, AND STARS

PERHAPS no poet in ancient or in modern times has invoked Urania [1] under happier auspices than Milton; no other poet has drunk so deeply of her inspiration, or has with greater felicity described the shining orbs that people the realms over which the celestial goddess wields her gentle sway.

The science which treats of the mechanism of the heavens, and especially that branch known as 'observational astronomy,' proved itself an unfailing source of pure delight to Milton's devoutly poetical mind. For no poet has introduced into his writings with such frequency, and with such pleasing effect, so many passages descriptive of the beauty and grandeur of the heavens; no other poet by the creative effort of his genius has soared to such a height, nor has he ever been excelled in his descriptions of the celestial orbs, and of the beautiful phenomena associated with their varied motions.

The charm and attractiveness of Milton's utter-

[1] In classical mythology, Urania was known as the goddess of astronomy.

ances would perhaps be enhanced if a brief up-to-date description were first given of the more important celestial objects that commanded the admiration of the poet, for many wonderful discoveries have been made in astronomy since the days when Milton lived three centuries ago.

The Orb which first claims our attention is

The Sun

The surpassing splendour of the Sun when compared with that of any of the other orbs of the firmament is not more impressive than is his stupendous magnitude and the important functions which it is his prerogative to fulfil. Situated at the centre of our system, of which he may be regarded as both 'eye and soul,' this glorious sphere not only retains by his attractive power the Earth and planets in their orbits, but is also the primary source of all the vital, chemical, and mechanical forms of energy with which we are familiar on Earth. With prodigal liberality he dispenses his vast stores of light and heat which illumine and vivify the worlds that circle round him, and upon the constant supply of which all animated beings depend for their existence. Deprived of the light and heat of the Sun, our globe would be enveloped in perpetual darkness, and all living things would hopelessly perish.

The distance of the Sun from the Earth is about 93 million miles. The orb rotates on his axis in 25 days 8 hours; the velocity of rotation at the equator being 4407 an hour. The force of gravity

at the solar surface is 27·6 greater than on the Earth. A body weighing one pound at the Earth's equator would, if transferred to the Sun, weigh twenty-nine pounds. Consequently a human being of ten stone weight would, at the Sun's surface, have to overcome a resistance of about two tons before he could move.

The Sun's magnitude wholly baffles our conceptions. The great luminary has a diameter of 867,000 miles, and its mass is 745 times greater than that of all the planets combined. It exceeds the Earth in weight 330,000 times, and in volume 1,300,000 times; but its density is only one quarter that of our globe, an indication that the Sun is mainly a gaseous body. The dimensions of the orb are such that if we imagine it to be a hollow sphere with the Earth at its centre, there would be ample space within for the Moon to perform her revolutions, and room for a second satellite to revolve at a farther distance of 190,000 miles from its primary. Uranus and his four moons could be similarly accommodated, and so also could Jupiter with his two inner Galilean satellites.

The brilliance of sunlight is the intensest known. It far excels that of calcium light, nor can the electric arc be compared to the intrinsic radiance of this 'inconceivable effluence.'

Solar heat is seven or eight times more intense than that of any furnace known to art, and is capable of dissipating, or of converting into vapour, the most refractory of terrestrial substances. The quantity of light and heat emitted by the Sun is beyond

calculation, but only a very infinitesimal portion of this radiant energy is intercepted by the Earth and planets, the remainder being diffused throughout space where it most probably subserves purposes unknown to us.

In describing the physical structure of the Sun, it is usual to begin with the *photosphere*—the dazzling luminous envelope that indicates to the naked eye the boundary of the solar disc.

The Photosphere, when viewed with a telescope of low power, presents a smooth surface, but when observed with an instrument of high magnifying capacity its structure is seen to be complex. It is composed of brilliant granules and dusky interstices which represent areas of unequal brightness. The granules are believed to be the vividly incandescent summits of up-rushing masses of glowing vapour not exceeding one hundred miles in diameter. They comprise one-fifth of the Sun's surface and emit *three-fourths of the light. The comparatively dark* 'pores' or dusky interstices are similar descending currents which, having radiated their energy, are returning to be reheated underneath the surface of the photosphere. The photospheric clouds may be compared to the masses of aqueous vapour that float in the Earth's atmosphere, but on the Sun the droplets are those of incandescent metals. The depth of the photosphere is unknown, nor can it be ascertained if any boundary line separates it from the dark body of the Sun which it encloses like a luminous shell.

Dark patches of irregular form and size are frequently seen on the Sun's disc. They are called 'sun-spots,' and are believed to be rents or depressions in the photosphere. A typical sun-spot consists of a dark cavity called the 'umbra,' within which is a still darker nucleus, and surrounding them is a

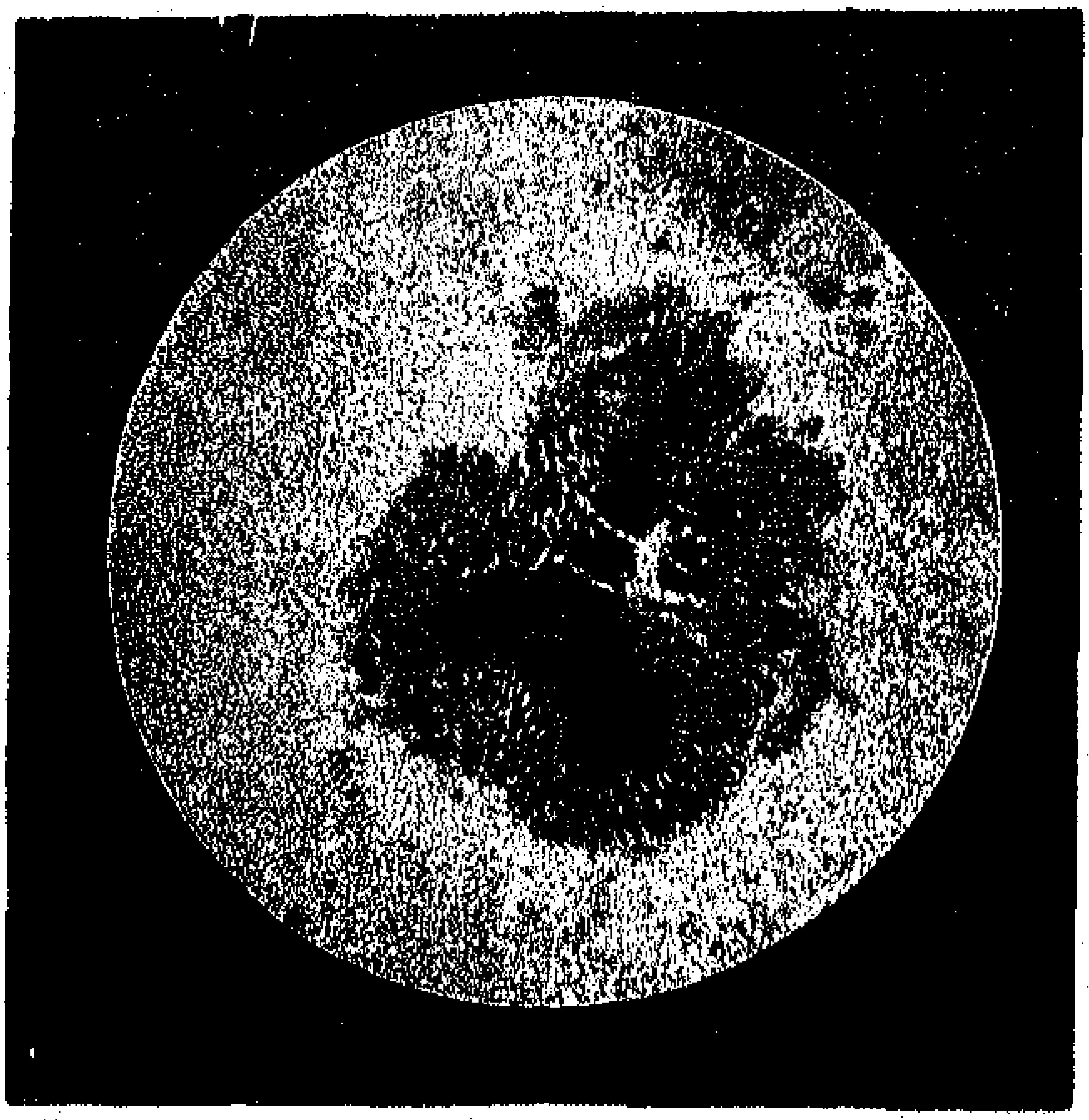
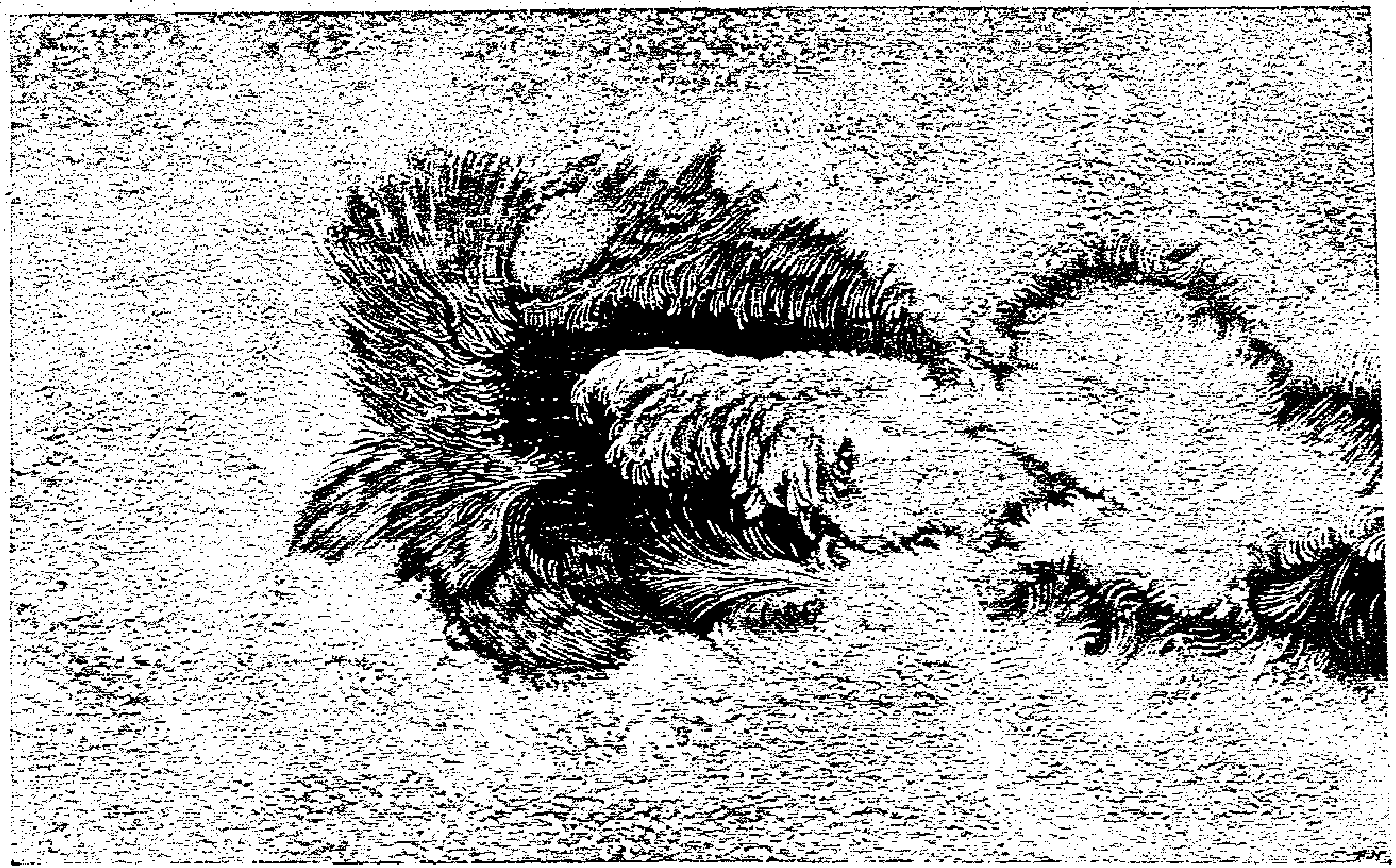


FIG. 3.—A Sun-spot magnified (*Janssen.*)

faintly luminous fringe of filaments radiating inwards called the 'penumbra.' The penumbra is brightest at its inner edge, where the filaments present a marked contrast to the dark cavity of the umbra which they surround and overhang. Occasionally lengthened processes unite with those of the opposite side and form bands, or 'bridges,' across the umbra.



A TYPICAL SUN-SPOT

One penumbra sometimes encloses several umbræ, whilst the nuclei may be entirely absent.

Sun-spots usually occur in groups. Large isolated spots are comparatively rare, but when present are frequently followed by a train of smaller spots of less perfect form. Prior to the appearance of a spot an unusual disturbance of the solar surface over its site is indicated by the presence of luminous ridges of photospheric matter called 'faculæ,' and of dark pores, between which greyish patches appear that seem to lie underneath a thin layer of the photosphere. These, when dissipated, disclose the presence of a fully formed spot. The duration of a sun-spot varies from a few hours to several months; long-lived spots rotate with the Sun, disappearing and re-appearing with each revolution of the orb until they cease to exist. The life of a sun-spot is terminated by a rush of luminous photospheric matter that overwhelms the penumbra and fills up the umbra, causing the spot to disappear.

Sun-spots vary greatly in size; some have a width of only a few hundred miles, whilst others attain enormous dimensions. In some spots the umbra alone has a diameter of 20,000 or 30,000 miles, disclosing a chasm sufficiently large to engulf a globe several times the size of the Earth. A group of spots, including their penumbræ, will occupy an area of the Sun's surface embracing many millions of square miles.

Although the changes that occur in sun-spots and faculæ appear slow when observed through

the telescope, yet in reality they are not. Tremendous storms and cyclones of intensely heated gases, which may be compared to the flames arising from a great furnace, sweep over different areas of the Sun with a velocity of hundreds of miles an hour. Vast ridges and crests of incandescent vapours are upheaved by the action of internal heat, which exceeds in intensity the temperature at which the most refractory of terrestrial substances can be volatilised, and down-rushes of the same photospheric matter take place after having parted with some of its stores of thermal energy. Sun-spots have been observed to grow rapidly, and then disappear in a very short period: a spot has been seen to divide into two or more portions, the fragments flying asunder with a velocity of not less than one thousand miles an hour. It is by these vast upheavals and convulsions of the photosphere that the light and heat are maintained which illumine and vivify the worlds that gravitate round the Sun.

During a total solar eclipse, when the Sun is hidden for a few minutes behind the dark body of the Moon, certain objects become visible which indicate that the volume of the orb is not confined within the circumference of the photosphere, but extends far beyond it. Indeed, the Sun has been appropriately described as 'the bright spherical nucleus of a nebulous body,' and it is only at the moment of totality that its nebular surroundings come into view. These consist of flames, beams, silvery streams, and luminous clouds of highly

attenuated matter that occupy a vast region of space extending far beyond the limits of the photosphere.

The CHROMOSPHERE constitutes the base of this solar effluence. It completely surrounds the photosphere to a depth of about four thousand miles, and may be appropriately described as an ocean of fire over which the tufted summits of scarlet flames sway violently to and fro as if agitated by gusts of fiery winds. The chromosphere, when seen in profile at the edge of the Sun's disc, presents an irregular serrated appearance—an effect created by towering masses of flame inaptly termed 'prominences,' which are visible over its entire circumference, and give rise to the impression of a vast conflagration. These masses of flame, which consist chiefly of glowing hydrogen, shoot upward with amazing velocity, and attain an altitude of twenty, thirty, fifty, and sometimes one hundred thousand miles in the space of a few hours. They are, however, of transient duration, change rapidly in form and appearance, and die down in a comparatively short time. These fiery outbursts testify to the violence of the convulsions that rend the solar atmosphere, where incandescent metallic vapours and intensely heated gases represent the clouds and winds with which we are familiar on Earth.

The CORONA is a beautiful aureole of light that becomes visible when the Sun is hidden behind the dark body of the Moon. It is a highly attenuated expansion of the solar constituents, and reaches a distance of several degrees beyond the Sun's visible

surface. This radiant object consists of beams, streaks, luminous filaments, and sheets of pearly light, the whole forming an irregular stellate halo, having the dark globe of the Moon in its centre.

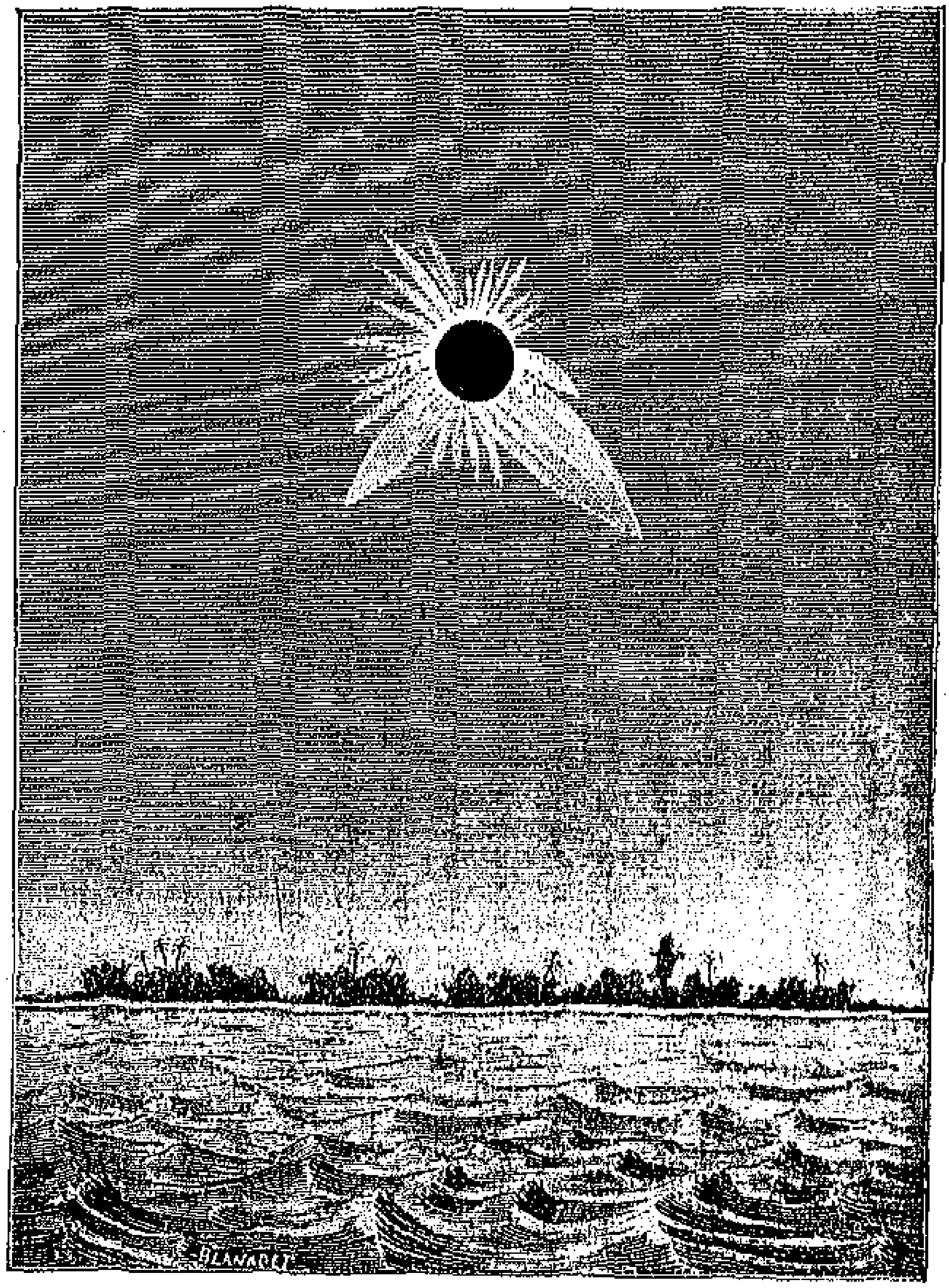


FIG. 4.—The Corona during the Eclipse of May 1883.

The inner portion of the corona is fairly uniform in appearance, and forms a ring three or four minutes of arc in width. The outer part is much more irregular in shape and extends a much greater distance.

It varies at maximum and minimum sun-spot periods. During the minimum period it is smaller and more extended towards the poles; at the maximum it is most fully developed over the spot zones from which great luminous bands emanate resembling wings or shining aigrettes. The corona surrounds the Sun to *a distance of several hundred thousand miles. Its* chief constituents are hydrogen, helium, calcium, and coronium, a substance of unknown chemical meaning that emits a green ray. Finely divided shining particles of matter, and electrical discharges resembling those of an aurora also assist in its illumination.

The investigation of the chemical constitution of the Sun by means of the spectroscope has in recent years made rapid progress. In a published list of thirty-six solar elements are included, barium, calcium, carbon, chromium cobalt, hydrogen, iron, lead, magnesium, potassium, sodium, silver, zinc, and numerous other terrestrial elements. The solar element 'helium' was unknown terrestrially until March 1895, when Professor Sir W. Ramsay extracted it by means of heat from the rare Norwegian mineral 'cleveite.' The presence of oxygen, nitrogen, and argon has not yet been declared, but negative results obtained with the spectroscope afford no reasonable evidence that they are non-existent in the Sun.

Of the central nucleus or body of the Sun which constitutes nine-tenths of its mass, we possess no definite knowledge, for we have no terrestrial analogy to guide us in which way matter would behave when subjected to such extremes of heat

and pressure as prevail in the interior of the Sun. Nevertheless, we should not greatly err in concluding that the Sun is mainly a gaseous sphere which is slowly contracting, and that a portion of the energy expended in this process is being transmuted into heat so extreme as to render the orb a great fountain of light.

It is remarkable with what frequency Milton alludes to the Sun. This is most apparent in the 'Paradise Lost,' which contains numerous references to the orb, all of which testify to the poet's accurate conception of his unrivalled splendour, and of his supreme importance in the system which he upholds and governs. Milton never fails to refer to the Sun as being the prime source of light and heat; and in depicting scenes of animation and joy within the cosmos, he always introduces the orb's brilliant radiance, upon the presence of which, the beauty and attractiveness of all natural phenomena so greatly depend. Occasionally the Sun is laid under contribution in order to illustrate a simile, or to enhance by comparison the reader's conception of some great event or sublime spectacle. Milton's partiality for light may in some degree be ascribed to his affliction, for, doubtless, the most pleasing sensation impressed upon the memory of the blind poet was his vivid remembrance of the Sun's brilliance and luminosity.

What Milton's sentiments were regarding light may be best ascertained by referring to the noble

passage with which he begins Book iii. of the 'Paradise Lost':

Hail, holy Light; offspring of Heaven first born!
Or of the Eternal co-eternal beam
May I express thee unblamed? since God is light,
And never but in unapproachèd light
Dwelt from eternity, dwelt then in Thee,
Bright effluence of bright essence increate!
Or hear'st thou rather pure Ethereal stream,
Whose fountain who shall tell? Before the Sun,
Before the Heavens, thou wert, and at the voice
Of God, as with a mantle, didst invest
The rising World of waters dark and deep,
Won from the void and formless Infinite!
Thee I revisit now with bolder wing,
Escaped the Stygian Pool, though long detained
In that obscure sojourn, while in my flight,
Through utter and through middle Darkness borne,
With other notes than to the Orphean lyre
I sung of Chaos and eternal Night;
Taught by the Heavenly Muse to venture down
The dark descent, and up to reascend,
Though hard and rare. Thee I revisit safe,
And feel thy sovran vital lamp; but thou
Revisit'st not these eyes, that roll in vain
To find thy piercing ray, and find no dawn;
So thick a drop serene hath quenched their orbs,
Or dim suffusion veiled. Yet not the more
Cease I to wander where the Muses haunt
Clear spring, or shady grove, or sunny hill,
Smit with the love of sacred song; but chief
Thee, Sion, and the flowery brooks beneath,
That wash thy hallowed feet, and warbling flow,
Nightly I visit: nor sometimes forget
Those other two equalled with me in fate,
So were I equalled with them in renown,
Blind Thamyris and blind Mæonides,
And Tiresias and Phineus, prophets old:
Then feed on thoughts, that voluntary move

Harmonious numbers; as the wakeful bird
Sings darkling, and, in shadiest covert hid,
Tunes her nocturnal note. Thus with the year
Seasons return; but not to me returns
Day, or the sweet approach of even or morn,
Or sight of vernal bloom, or summer's rose,
Or flocks, or herds, or human face divine;
But cloud instead and everduring dark
Surrounds me, from the cheerful ways of men
Cut off, and from the book of knowledge fair,
Presented with a universal blank
Of Nature's works, to me expunged and rased,
And wisdom at one entrance quite shut out.
So much the rather thou, celestial Light,
Shine inward, and the mind through all her powers
Irradiate; there plant eyes, all mist from thence
Purge and disperse, that I may see and tell
Of things invisible to mortal sight.—iii. 1–55.

Samson's lamentation over his blindness is but an echo of the poet's own feelings:

O dark, dark, dark, amid the blaze of noon
Irrecoverably dark.—S. A. 80–1.

In his narrative of the creation, Milton mentions the Sun as having been the first of the celestial orbs that God called into existence:

For, of celestial bodies, first the Sun
A mighty sphere he framed, unlightsome first,
Though of ethereal mould.—vii. 354–56.

The orb remained opaque and non-luminous until God—

Of light by far the greater part he took,
Transplanted from her cloudy shrine, and placed
In the Sun's orb, made porous to receive
And drink the liquid light, firm to retain
Her gathered beams, great palace now of light.
vii. 359–63.

The Sun having become luminous, Milton describes his setting out on his journey:

> First in his east the glorious lamp was seen,
> Regent of day, and all the horizon round
> Invested with bright rays, jocund to run
> His longitude through heaven's high road.—vii. 370-73.

According to the Mosaic cosmology, the first creation was Light. 'And God said, Let there be light: and there was light.' The celestial orbs He created on the fourth day. Milton says that the greater part of this light, which, like a radiant cloud, was diffused over the newly created Universe, God concentrated in the body of the Sun, which became a great fountain of light, and as such illumined all surrounding objects with his rays when pursuing his great path in the heavens. The poet's utterances as regards the Sun's primal origin and subsequent luminosity are not based on any cosmological system, nor supported by Scriptural testimony, but are the outcome of a free use of his imagination, and indulgence in poetical licence.

In the following citation we have an example of the versatility of Milton's poetical genius, when he essays to describe the physical structure and immediate surroundings of the Sun.

Satan, when pursuing his way among the stars, is attracted by the Sun's splendour; thither he directs his flight, and lands in the orb:

> The place he found beyond expression bright,
> Compared with aught on Earth, metal or stone—
> Not all parts like, but all alike informed

With radiant light, as glowing iron with fire.
If metal, part seemed gold, part silver clear;
If stone, carbuncle most or chrysolite,
Ruby or topaz, to the twelve that shone
In Aaron's breast-plate, and a stone besides,
Imagined rather oft than elsewhere seen—
That stone, or like to that, which here below
Philosophers in vain so long have sought;
In vain, though by their powerful art they bind
Volatile Hermes, and call up unbound
In various shapes old Proteus from the sea,
Drained through a limbec to his native form.
What wonder then if fields and regions here
Breathe forth elixir pure, and rivers run
Potable gold, when, with one virtuous touch
The arch-chemic Sun, so far from us remote
Produces, with terrestrial humour mixed,
Here in the dark so many previous things
Of colour glorious, and effect so rare?
Here matter new to gaze the Devil met
Undazzled. Far and wide his eye commands;
For sight no obstacle found here, nor shade
But all sunshine, as when his beams at noon
Culminate from the equator, as they now
Shot upward still direct, whence no way round
Shadow from body opaque can fall; and the air,
Nowhere so clear, sharpened his visual ray
To objects distant far.—iii. 591–621.

This ornate and vivid description of the Sun, although purely imaginative and embellished with allusions illustrative of classical and mythological fable, would seem to indicate that Milton had some notion of the volatile conditions under which matter exists in the orb. The poet upheld the belief in the transmutation of matter from lower to higher conditions—the grosser fed the purer—and the Sun the highest orb, in return for his light, received

'alimental recompense' from all the lower orbs (v. 415–26). Everywhere on the Sun all matter glowed with heat and radiant light, but the poet had no knowledge of the solar elements, nor of the conditions under which they exist. The intense luminosity of metallic vapours, and the brilliance of incandescent gases were unknown to him; consequently in describing the solar contents he had recourse to terrestrial substances well known for their lustre and brilliancy; but the existence of these in the Sun he merely surmises, or suggests what might be their resemblance. If metal, part seemed gold, part silver; if stone, the scintillation of precious gems represented the solar effluence. One stone in particular is mentioned by Milton as being present in the Sun, viz. the philosophers' stone. The alchemist with his furnace, his crucibles, and alembics, although capable of distilling and solidifying the volatile metal mercury (Hermes) and of reducing to their elementary conditions various chemical compounds elusive as the sea-god Proteus, was unable to produce this substance which was believed to possess the power of transmuting all other metals into gold. The poet adds, what wonder then, if on the Sun are fields and regions that breathe forth elixir pure—a fluid once supposed to have the power of indefinitely prolonging life, and rivers of potable gold—*aurum potabile*, a liquid regarded by alchemists as *elixir vitae*, and prepared by dissolving the royal metal in *aqua regia*—when the arch-chemic Sun so far removed can produce on Earth such marvellous

effects and impart to terrestrial substances such vitalising and life-sustaining properties.

In the midst of this new and intensely luminous matter the Devil landed, and gazed upon undazzled; nor was any shadow present to obstruct his field of vision, but all was sunshine as when the solar rays at noon shoot vertically downward on the terrestrial equator, so here they shot directly upward intercepted by no visible shadow of any object that might restrict one's view. In Milton's time chemistry was unknown as a science, and oxygen, hydrogen, and nitrogen had not been discovered. But the poet possessed some knowledge of the refinement and sublimation of matter when exposed to extreme heat, a condition applicable to the solar elements from which emanated intensely luminous rays, rendering the orb a great source of light. Our knowledge of the Sun, although much more definite and comprehensive as regards details, does not greatly exceed what has been so happily surmised by the poet.

In describing Satan's progress among the stars, Milton says:

> Above them all
> The golden Sun, in splendour likest Heaven,
> Allured his eye.—iii. 571–73.

and after having landed on Mount Niphates, he is represented as looking—

> Sometimes towards Heaven and the full blazing Sun,
> Which now sat high in his meridian tower.—iv. 32–39.

Satan then addresses the Orb:

O thou that, with surpassing glory crowned,
Look'st from thy sole dominion like the god
Of this new World; at whose sight all the stars
Hide their diminished heads; to thee I call,
But with no friendly voice, and add thy name,
O Sun, to tell thee how I hate thy beams,
That bring to my remembrance from what state
I fell, how glorious once above thy sphere,
Till pride and worse ambition threw me down,
Warring in Heaven against Heaven's matchless King!
iv. 32–41.

In alluding to the faded splendour of the fallen Archangel, Milton compares him to the Sun when seen under conditions that temporarily deprive him of his glory:

as when the Sun new-risen
Looks through the horizontal misty air
Shorn of his beams, or from behind the Moon,
In dim eclipse, disastrous twilight sheds
On half the nations, and with fear of change
Perplexes monarchs.—i. 594–99.

These lines testify to the sublimity of Milton's imagination, and to his skill in adapting the grandest phenomena in Nature to the illustration of his subject.

Prior to participating in the contest in Heaven—

The Apostate in his sun-bright chariot sat,
Idol of majesty divine.—vi. 100–1.

and in the combat between Michael and Satan—

two broad suns their shields
Blazed opposite.—vi. 305–6.

When describing objects of marked brilliancy, Milton frequently compares them to the Sun, whose dazzling radiance surpasses that of all other celestial orbs.

Associated with the Sun's diurnal journey across the heavens are the different periods of the day —morning, noontide, and evening. To a mind so susceptible of the beautiful as that of Milton's, these pleasing vicissitudes in Nature were a perpetual source of enjoyment and delight. The following citations felicitously express his sentiments with regard to Morning:

> Thus passed the night so foul, till Morning fair
> Came forth with pilgrim steps, in amice grey,
> Who with her radiant finger stilled the roar
> Of thunder, chased the clouds, and laid the winds.
> P. R. iv. 426-29.

> Meanwhile,
> To re-salute the World with sacred light
> Leucothea waked, and with fresh dews embalmed
> The Earth.—xi. 133-36.

> till morn
> Waked by the circling Hours, with rosy hand
> Unbarred the gates of light.—vi. 2-4.

> Now Morn, her rosy steps in the eastern clime
> Advancing, sowed the Earth with orient pearl.—v. 1-2.

With these aspects of Morning, Milton was not unfamiliar, for he was an early riser, and must have frequently witnessed the dispersal of Aurora's fan—

> Under the opening eyelids of the Morn.—L. 26.

The rising Sun, when he first casts his beams upon the newly awakened Earth, is depicted as follows:

> Soon as they forth were come to open sight
> Of day-spring, and the Sun, who, scarce up-risen,
> With wheels yet hovering o'er the ocean-brim,

Shot parallel to the Earth his dewy ray,
Discovering in wide landskip all the east
Of Paradise and Eden's happy plains.—v. 138-43.

Again:

As when a scout,
Through dark and desert ways with peril gone
All night, at last by break of cheerful dawn
Obtains the brow of some high-climbing hill,
Which to his eye discovers unaware
The goodly prospect of some foreign land
First seen, or some renowned metropolis
With glistering spires and pinnacles adorned,
Which now the rising Sun gilds with his beams.
iii. 543-51.

And now the Sun with more effectual beams
Had cheered the face of earth, and dried the wet
From drooping plant, or dropping tree.—
P. R. iv. 432-34.

The heat of noon-day and the sultriness experienced when the Sun has crossed the meridian are referred to by Milton when he describes Raphael's visit to Adam's abode:

Him, through the spicy forest onward come,
Adam discerned, as in the door he sat
Of his cool bower, while now the mounted Sun
Shot down direct his fervid rays, to warm
Earth's inmost womb, more warmth than Adam needs.
v. 298-302.

Having advanced to meet his celestial visitor, Adam invites him—

in yonder shady bower
To rest, and what the Garden choicest bears
To sit and taste, till this meridian heat
Be over, and the Sun more cool decline.—v. 367-70.

After having entertained his angel-guest, Adam

expresses a desire to be informed of certain momentous events that occurred in Heaven, and in urging his request, says:

> And we have yet large day, for scarce the Sun
> Hath finished half his journey, and scarce begins
> His other half in the great zone of heaven.—v. 558-60.

The declining day, and approach of evening, have provided poets with a theme upon which they have lavished their choicest expressions of admiration and delight. In his portrayal of these, Milton is not behind his compeers, for he was an ardent lover of Nature in all her aspects. The following passages reflect the poet's sentiments when he describes the setting Sun:

> Meanwhile in utmost longitude, where Heaven
> With Earth and Ocean meets, the setting Sun
> Slowly descended, and with right aspect
> Against the eastern gate of Paradise
> Levelled his evening rays.—iv. 539-43.

Having descended to Earth on a sunbeam, in order to warn Gabriel of the presence of Satan—

> Uriel to his charge
> Returned on that bright beam, whose point now raised
> Bore him slope downward to the Sun, now fallen
> Beneath the Azores; whether the Prime Orb,
> Incredible how swift, had hither rolled
> Diurnal, or this less volubil Earth,
> By shorter flight to the east, had left him there,
> Arraying with reflected purple and gold
> The clouds that on his western throne attend.—iv. 589-97.

Here, Milton touches upon the two rival astronomical theories known as the Ptolemaic and Copernican. He hesitates to affirm whether it is

the departing Sun that accomplishes a diurnal revolution round the Earth, or the Earth that, by rotating on her axis from west to east, leaves the stationary Sun behind. Although Milton adopted the Ptolemaic system for the requirements of his poem, he was yet well aware of the scientific reasonableness of the Copernican hypothesis.

The coming on of evening in Paradise, and the departure of Raphael from thence, are felicitously described by the poet. The Angel, in ending his conversation with Adam, says:

> But I can now no more; the parting Sun
> Beyond the Earth's green Cape and verdant Isles
> Hesperian sets, my signal to depart.—viii. 630–32.

And again:

> Now was the Sun in western cadence low
> From noon, and gentle airs due at their hour
> To fan the Earth now waked, and usher in
> The evening cool.—x. 92-5.

> And now on Earth the seventh
> Evening arose in Eden—for the Sun
> West set, and twilight from the east came on
> Forerunning night.—vii. 581-84.

In 'Arcades' the Genius of the Wood says:

> When evening grey doth rise, I fetch my round
> Over the mount, and all this hallowed ground,
> And early, ere the odorous breath of Morn
> Awakes the slumbering leaves or tasselled horn
> Shakes the high thicket, haste I all about.
> A. 54–8.

It is seldom that Milton introduces any humorous allusion in his poems, but the following, which

applies to the Sun, may be justly regarded as decidedly humorous, or highly fantastic:

> So when the Sun in bed,
> Curtained with cloudy red,
> Pillows his chin upon an orient wave,
> The flocking shadows pale
> Troop to the infernal jail.—H. 229-33.

The Sun is the most glorious object in Nature. There are other suns in other skies, but they do not encroach upon the 'sole dominion' of the refulgent orb, that in his proud isolation knows no peer and fears no rival. It is interesting to read what a great poet has to say of the Sun, and if we may conclude from the numerous passages just cited, it is apparent that the orb has received ample justice at the hands of Milton, who has depicted his glories in numbers that possess the prime charm of poetic accuracy associated with sublimity of thought and felicity of expression. Everywhere throughout his poems, Milton accords the Sun that pre-eminence among the orbs of the firmament which is his due; he extols his 'surpassing glory' and delights in the portrayal of scenes and objects whose attractiveness and varied beauty are dependent upon the brilliant radiance emitted by the peerless orb.

The Moon

The Moon is the Earth's satellite, and, with the exception of the Sun, is the most useful of the celestial orbs that minister to the requirements of Man. Besides affording us light in the night, the Moon

is the principal cause of the ebb and flow of the tides—a phenomenon of much importance to navigators.

The mean distance of the Moon from the Earth is about 240,000 miles. In form, the orb is almost a perfect sphere, and is 2160 miles in diameter. The density of the Moon is 3·57 that of water, or 0·63 that of the Earth, consequently the lunar constituents are less dense than the terrestrial in the proportion of about three to five. The area of the lunar surface is about one-thirteenth that of the Earth. Fifty globes, each as large as the Moon, would be required to equal one the size of the Earth. The Moon travels with a velocity of 2273 miles an hour, and accomplishes a revolution round the Earth in 27 days, 7 hours, 43 minutes. The orb in the same period of time completes a rotation on her axis; owing to this synchrony of rotation and revolution the same hemisphere is always directed towards the Earth. The form of the Moon's orbit is that of an ellipse with the Earth in the lower focus. The orb changes her shape and position in the sky with marked rapidity, and among primitive and uncivilised races was the most useful of the heavenly bodies in the measurement of time.

The changes in form which the Moon presents on her monthly journey round the Earth are called her phases. They are always interesting and very beautiful. The orb is first seen in the west after sunset as a delicate slender crescent of pale light having her convex edge directed towards the Sun.

Each day her angular distance from the Sun, and the width of her crescent increase until at the expiration of seven days, having then traversed a fourth part of the circumference of her orbit, she appears as a semicircle or half-moon, and is in quadrature. Continuing her eastward progress a further extent of her illumined surface becomes visible, which is greater than half a circle; the Moon is then said to be gibbous. Still pursuing her path round the Earth, the Moon at the end of the second week, having travelled half the circumference of her orbit, comes into opposition with the Sun. The whole of her illumined hemisphere is now visible as a circular disc of light, and the Moon is described as being full. After full Moon, the orb in a reverse manner passes through the same phases, and in her last quarter again assumes the crescent form in the morning heavens, growing less and less until lost in the Sun's rays—afterwards to re-appear in a few days, and on her monthly round to undergo the same cycle of changes. The convex edge of the crescent is always turned towards the Sun.

The Moon's changes of form from a slender crescent to that of a circular disc of light are due conjointly to her spherical figure, her motion round the Earth, and also to the fact that the orb is a dark body illumined by the Sun's rays. On account of her globular shape, one half of the Moon's surface is bathed in sunlight, and the other half is enveloped in darkness, consequently we see more or less of her illumined hemisphere as she changes her position

in the sky with regard to the Sun. When opposite to the orb the Moon is visible as a globe, and when in her first and last quarters she appears as a crescent.

Apart from her phases, the Moon can be observed to successively occupy widely remote regions of the sky, changing her position like a drifting cloud, but with a much less rapid motion. Sometimes the Moon is west, sometimes east of the Sun; at other times she is north, and again south of the orb. These wanderings of our satellite over the face of the sky are due to two motions: (1) a west to east motion that is steady and continuous, and which carries the Moon round the Earth in 29·53 days, being the interval that elapses between two successive new or full Moons, and is termed her *synodical* period; (2) a north and south motion consequent upon the intersection at an angle of $5° 8' 40''$, of the plane of the ecliptic by that of the lunar orbit. The two points of intersection are called the *nodes* and the line connecting them the *line of nodes*. The changing position of the ecliptic with respect to the horizon has also to be considered. Observers of the heavens will have doubtless perceived that the Moon when of the same age appears much farther south at one period of the year than at another. This is due to the fact that the ecliptic in its relation to the horizon is differently situated at a given time of night at different seasons of the year. When the Sun is at the winter solstice he sets low down in the south-west, consequently the Moon—whose course never deviates far from the Sun's path—when new is in the same

part of the heavens, but when full, the orb rises far in the north-east in the opposite region of the sky and rides high in the heavens as may be seen at midwinter. At midsummer the reverse occurs, the new Moon appears high in the sky and the full Moon travels low down towards the horizon.

In consequence of this beneficent arrangement, we have the greatest quantity of light at night from the full Moon in winter, when the orb travels high and remains for a long time above the horizon. In summer, when the Sun is long above the horizon, we have least moonlight. In March the evenings have least, and in September most moonlight. In the polar regions, when the Sun is absent, and the night constant, the Moon, during her second and third quarters—embracing the season of full Moon—is continuously above the horizon, thus compensating in a small degree for the absence of the Sun; while in the summer, when the Sun remains above the horizon, and the light of the Moon is not required, the orb is only above the horizon during her first and last quarters when her light is least. But the inhabitants of the other hemisphere from whom the sunlight is withdrawn enjoy the greatest amount of her light.

About the time of the autumnal equinox, the Moon, when near her full, rises for several successive nights about sunset. This occurrence gives rise to a number of brilliant moonlight evenings which in the north temperate zone happen at the time of harvest; and the phenomenon is called the *harvest moon.* Its

return is hailed with joy by the peasantry, and is celebrated by a festival called the *harvest home*. The same phenomenon occurs in October, but in a less marked degree; it is then known as the *hunter's moon*.

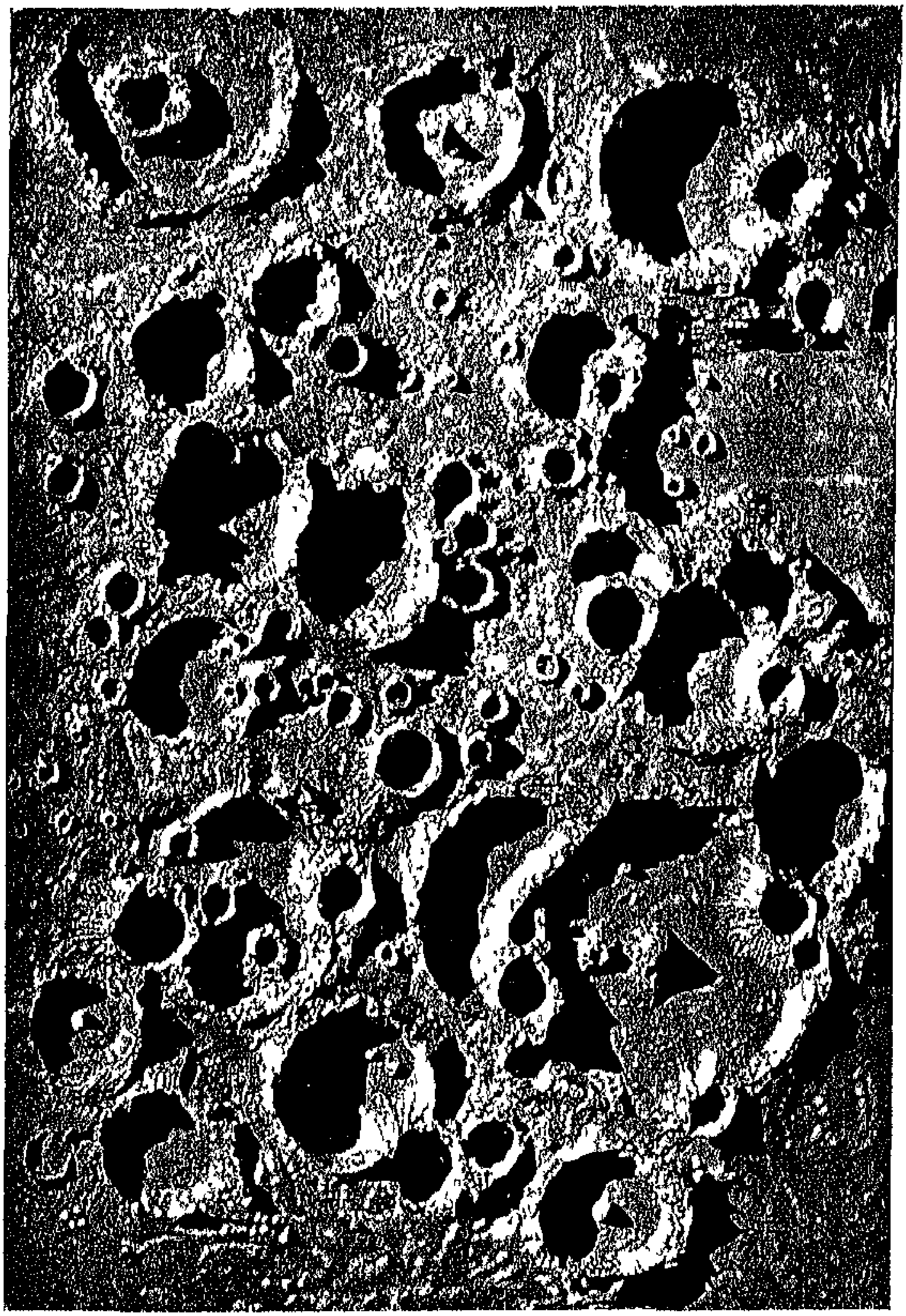
This succession of brilliant moonlight evenings depends upon the small angle of inclination of the lunar orbit to the horizon when the full Moon is crossing the equator from south to north at the equinoctial point.

The Moon is in no sense a duplicate of her primary, and no analogy exists between the Earth and her satellite. Evidence of the presence of a lunar atmosphere is wanting. No clouds nor vapours can be perceived, and it is believed that no water exists on the surface of the orb. Indeed, all the conditions essential for the support and maintenance of organic life with which we are familiar on Earth appear to be non-existent on the Moon. Our satellite has no seasons. Her axial rotation is so slow that one lunar day is equal in length to fourteen of our days, and this long period of sunshine is succeeded by a night of similar duration. The alternate recurrence of such long days and nights subjects the lunar surface to great extremes of heat and cold, and owing to the absence of a protective atmosphere which would prevent the rapid radiation of heat into space, it is believed that the lunar temperature during the Moon's long night sinks to absolute zero. Desolation and solitude are characteristic of the Moon, whose arid surface appears incapable of sustaining the lowest forms of organic life.

The Moon when viewed through a telescope presents to our gaze lofty mountain-chains with rugged peaks; numerous extinct volcanoes called crater-mountains, and vast level plains—a region of desolation consisting of the shattered and upturned fragments of the Moon's crust convulsed by forces of a volcanic nature that have long since expended their energies and died out.

The mountain ranges resemble those of the Earth, but have a more rugged outline, and their peaks are more precipitous, for, in consequence of the absence of the disintegrating effects of water, and the fury of tempests, they retain their primitive sharpness unaffected by the hand of time. They are called the lunar Alps, Apennines, and Cordilleras, and embrace every variety of hill, cleft, and ridge, some of their summits attaining a height of 20,000 feet.

The crater-mountains are, however, the most striking features of the Moon's surface; in some regions they are so numerous that portions of the lunar disc appear honeycombed with them, and no fewer than 33,000 have been enumerated. They differ from those of the Earth inasmuch as they are circular areas or great walled plains, each having in its centre an elevated peak, and its circumference bounded by a rocky annulus. Their floor lies much below the level of the adjacent surface, the interior depth being often several times greater than that of the exterior height. They vary in size from a few yards to 150 miles in diameter. Their origin is correctly ascribed to volcanic agency.



A PORTION OF THE MOON'S SURFACE

The plains are large level areas formerly believed to be seas. They are of a darker hue than the mountains which surround them, and are analogous to the deserts, steppes, and prairies of the Earth. They vary in extent, the dimensions of some being equal to those of an inland sea. The lunar valleys differ in length and width; some are spacious and broad, whilst others contract into mere gorges and chasms. Clefts, or fissures of considerable depth, extend for long distances across the Moon's strata, and are a result of the shrinkage of the lunar substance when undergoing the process of cooling.

Although the face of the Moon has been carefully scanned for two centuries and a half, and selenographers have mapped and delineated her features with the utmost precision, yet no perceptible change of a reliable character has been perceived to occur on any part of the lunar surface. The hemisphere directed towards the Earth appears to be an alternation of craggy wildernesses, desert plains, and extinct volcanoes—a region of desolation unoccupied by any living thing, and upon which 'the light of life has never dawned.' On account of the absence of an atmosphere there is neither diffuse daylight nor twilight on the Moon, every portion of the lunar surface not exposed to the Sun's rays is shrouded in darkness, and black shadows can be observed fringing prominences of silvery whiteness. If our satellite were enveloped in an atmosphere similar to that by which the Earth is surrounded, the diffusion and reflection of light by the minute particles of aqueous

vapour that permeate it would give rise to a gradual transition from light to darkness—the lunar surface would then be visible when not illumined by the direct rays of the Sun, and before sunrise and after sunset, dawn and twilight would occur as upon the Earth. But on the Moon there is no dawn, and the darkness of night envelopes the orb until the edge of the Sun's disc appears above the horizon; then, his dazzling rays illumine the loftiest peaks of the lunar mountains whilst yet their sides and bases remain wrapped in deep gloom. Since there is no atmosphere on the Moon to diffuse or reflect her light, the Sun shines in a pitch-black sky, and at lunar noon-day the planets and constellations can be seen displaying a brilliancy of greater intensity than can be perceived on Earth during the darkest night. Every portion of the Moon's surface is bleak, bare, and untouched by any softening influences; no fitful gale ever sweeps down her valleys; no refreshing shower ever falls upon her arid mountains and plains; no cloud ever tempers the fierce glare of the Sun that pours down his rays from a sky of inky blackness; no sound ever breaks the profound stillness that reigns over this world of solitude and desolation.

None of the celestial orbs have had their charms and attractive aspects so frequently portrayed by poets as the Moon, whose silvery radiance dispels the all-pervading darkness that enshrouds the dominion of ancient Night; and who as queen of the firmament presides over the stellar multitude

that adorn her shadowy realm. Milton's appreciation of the charming visual effects that accompany the Moon's presence when above the horizon is frequently and felicitously expressed in numerous passages that testify to his keen perception of the pleasing recurrence of lunar phenomena.

In directing Satan to Earth, the archangel Uriel, Regent of the Sun, calls his attention to our globe's illumined hemisphere, and remarks that the other hemisphere night would invade—

> But there the neighbouring Moon
> (So call that opposite fair star) her aid
> Timely interposes, and, her monthly round
> Still ending, still renewing, through mid-Heaven,
> With borrowed light her countenance triform
> Hence fills and empties, to enlighten the Earth,
> And in her pale dominion checks the night.—iii. 726-32.

This concise description of the Moon's office in relation to her primary, and of the varied aspects she presents on her monthly journey, indicates that Milton fully appreciated the importance and usefulness of the orb as the Earth's satellite. The poet was well aware that the partial or complete illumination of the Moon's disc, giving rise to her triform appearance as crescent, half moon, and full moon, depended upon her position with regard to the Sun as observed by a spectator standing on Earth.

In the following passage a description of lunar motion is given that differs in several respects from that contained in the citation just referred to. Raphael, in his conversation with Adam in Paradise, mentions the Sun as having been the first created

of celestial bodies; and afterwards the Moon. The glorious orb in commencing his journey appeared first in the east, while—

> Less bright the Moon,
> But opposite in levelled west, was set,
> His mirror, with full face borrowing her light
> From him; for other light she needed none
> In that aspect, and still that distance keeps
> Till night; then in the east her turn she shines,
> Revolved on heaven's great axle, and her reign
> With thousand lesser lights dividual holds,
> With thousand thousand stars, that then appeared
> Spangling the hemisphere.—vii. 375–84.

At the time when the Sun was commencing his journey in the east, the Moon could be seen setting in the west, with full face reflecting his light, and this interval was maintained between the two orbs until 'revolved on heaven's great axle' the Moon in her turn rose in the east as the Sun set in the west. Consequently there was full moon every evening, nor was there any temporary disappearance of the orb from the sky. The Moon ruled the night similar to the way in which the Sun ruled the day—the days and nights being of equal length.

Raphael's description of the two prime orbs in their aspects and relationships is based upon their disposition prior to the Fall when there reigned upon Earth a perpetual spring. But we are told that after the first act of transgression the paths of the heavenly bodies were altered, presumably for the worse—

> To the blanc Moon
> Her office they prescribed.—x. 656–57.

It is in harmony with this re-arrangement of the celestial orbs that Uriel, when directing Satan to Earth, gives such a lucid description of the Moon's motions and phases. But the adverse changes in the physical Universe did not occur until some time after Satan's arrival upon the terrestrial globe. Chronologically, the poet is premature in describing the occurrence of lunar phenomena which at that time were not exhibited by the orb, and only became apparent after the general confusion that arose in Nature consequent upon the introduction of evil.

Cynthia is the classical name given to the Moon. Its derivation is from *Cynthus* (Mount) in Delos, which was the birthplace of the Moon-goddess Diana. She is represented as drawn in a chariot by a yoke of dragons, and having a crescent on her head.

Milton alludes to the Moon as Cynthia when directing attention to the entrancing music that greeted the ears of the shepherds at the Nativity, and which was also heard by Nature within the concave of the lunar orbit:

> Nature that heard such sound
> Beneath the hollow round
> Of Cynthia's seat, the airy region thrilling,
> Now was almost won
> To think her part was done,
> And that her reign had here its last fulfilling;
> She knew such harmony alone
> Could hold all Heaven and Earth in happier union.
>
> H. 101-8.

The Moon's path in the sky is often familiarly known by observing her relative position at certain

seasons with respect to some prominent object in the landscape such as a mountain-summit or wood-capped hill. A similar instance occurs in the case of a particular tree with which Milton was familiar, and over which he frequently observed the slowly-moving Moon travel—

> While Cynthia checks her dragon yoke,
> Gently o'er the accustomed oak.—Il P. 59-60.

Cynthia in listening to Philomel's song slackens her pace when passing over the well-known oak that probably stood in the garden at Horton.

The heathen goddess Astoreth, or Astarte, in her worship was symbolised by the Moon. She is represented as horned like the crescent moon; Milton alludes to her in the following lines:

> With these in troop
> Came Astoreth, whom the Phoenicians called
> Astarte, Queen of Heaven, with crescent horns;
> To whose bright image nightly by the Moon
> Sidonian virgins paid their vows and songs.—i. 437-41.

In the seventeenth century, the belief in witchcraft, demonology and sorcery was vigorously upheld by all classes; and many inoffensive persons were put to death for alleged participation in those occult practices. Referring to the gruesome deeds perpetrated by witches and night-hags, Milton describes the effect of their incantations upon the Moon:

> Nor uglier follow the night-hag, when, called
> In secret, riding through the air she comes,
> Lured with the smell of infant-blood, to dance
> With Lapland witches, while the labouring Moon
> Eclipses at their charms.—ii. 662-66.

In bygone ages it was believed that the Moon and heavenly bodies were influenced by magic, and by charms. The Moon could be affected in two ways: (1) by being drawn down nearer to the Earth; (2) by becoming eclipsed, i.e. withdrawing her light. The expression 'labouring moon' is classical, '*labores lunae*,' signifies eclipses of the orb; but the phrase might bear another interpretation, for the Moon would 'labour' strenuously in resisting any attempt to deflect her from her path. Her obscuration or eclipse would indicate the presence of vapour or cloud that intercepted her light.

The supposed influence of the Moon upon persons of feeble intellect finds expression in our language in the words 'lunatic' and 'moon-struck.' The latter is employed by Milton when he mentions the numerous maladies that afflicted the inmates of the lazar-house, whose miseries made Adam weep. In enumerating them the poet includes—

> Demoniac phrenzy, moping melancholy,
> And moon-struck madness.—x. 485 86.

The temporary invisibility of the Moon, when pursuing her monthly round, has inspired the Celtic poet Ossian with the sentiment that the solitary orb retires into darkness to mourn for her sisters who have fallen from Heaven. Milton alludes to the Moon as retiring into her cave. Samson in bewailing his blindness says:

> The Sun to me is dark
> And silent as the Moon,
> When she deserts the night,
> Hid in her vacant interlunar cave.—S. A. 86–9.

The Moon in ancient times was an object of worship, and the history of all nations teems with superstitions regarding our satellite, some of which are believed in still. The orb was supposed to exercise great influence over human affairs, and few undertakings were attempted without first referring to the age of the Moon. When the Moon was new, or at full, the season was considered favourable for embarking upon an enterprise, but when the orb was on the wane the time was regarded as inauspicious.

The dances and nocturnal revels of fairies and elves are usually described as having been held by moonlight. Those diminutive and graceful beings haunted woods and streams, and by their alleged capricious exploits and interference in the affairs of mortals have held a prominent place in the imagination of mankind. Milton was no stranger to Fairyland, nor to the quaint doings of its nimble inhabitants:

> The sounds and seas, with all their finny drove,
> Now to the Moon in wavering morrice move;
> And on the tawny sands and shelves
> Trip the pert fairies and the dapper elves.
>
> C. 115-18.

And again:

> or faery elves,
> Whose midnight revels by a forest side
> Or fountain, some belated peasant sees,
> Or dreams he sees, while overhead the Moon
> Sits arbitress, and nearer to the Earth
> Wheels her pale course.—i. 781-86.

The Moon and the belated peasant were the only spectators of these revels. The orb, situated

overhead, acted as arbitress or umpire in deciding the merits of the individual competitors who engaged in the sports and pastimes that formed part of the night's amusement. It was believed that those beings possessed the power of causing the Moon to describe her course nearer to the Earth.

There is an old and widespread superstition that ghosts and supernatural beings vanish on the approach of morning. The faeries then cease their revels—

> And the yellow skirted fays
> Fly after the night-steeds, leaving their moon-loved maze.
> II. 235–36.

Few persons fail to appreciate the beauty of a bright moonlight night. The calm, the impressive stillness, the hushed repose of animated beings, the overhead Moon flooding the Earth with her silvery radiance and transforming mountain, lake, and vale into fairyland, excite the most pleasing emotions combined with wonder and admiration that Nature in all her varied aspects should exhibit such loveliness.

Ossian addresses the Moon as 'Queen of the silent night'; and Milton says:

> now reigns
> Full-orbed the Moon, and, with more pleasing light
> Shadowy sets off the face of things—in vain
> If none regard.—v. 41–4

The poet in other descriptive passages, to which allusion is made elsewhere, expresses his high appreciation of the nocturnal beauty that accompanies the orb when describing her path in the heavens.

The Attendant Spirit in 'Comus,' concluding his epilogue, expresses himself thus:

> But now my task is smoothly done;
> I can fly, and I can run,
> Quickly to the green Earth's end,
> Where the bowed welkin slow doth bend,
> And from thence can soar as soon
> To the corners of the Moon.—C. 1012–17.

These numerous quotations descriptive of lunar phenomena testify to the pleasure which Milton derived from his observation of the varied appearances presented by the Moon when on her monthly journey round the Earth. Whether in referring to 'the pale reflex of Cynthia's brow,' or to the Sun's brilliant radiance, the poet is equally felicitous in depicting the distinctive glories peculiar to each orb. Milton delighted in astronomical phenomena, and especially in those associated with the Moon.

The Stars

The celestial vault, that, like a circling canopy of sapphire hue stretches overhead from horizon to horizon, resplendent by night with myriad stars of different magnitudes and varied brilliancy, forming clusterings and configurations of fantastic shape and beauty, arrests the attention of the most casual observer. But the impression conveyed to the mind of one who has studied the heavens and followed the efforts of human genius in unravelling the mysteries associated with those bright orbs, is one of wonder and longing to know more of their being,

and the hidden causes which brought them forth. Here, we have poetry written in letters of gold on the sable vestment of night; music in the gliding motion of the spheres; and harmony in the orbital sweep of sun, planet, and satellite.

On looking up to the heavens on a clear moonless night, one is impressed with the apparent countless number of the stars—so thickly studded is the firmament with glittering points of light—and yet if an attempt were made to enumerate them it would be found that it is seldom more than 2000 stars are together visible to the naked eye. Much depends upon sharpness of vision and the transparency of the atmosphere. Argelander counted at Bonn, 3237 stars; Houzeau at Jamaica, 5719; and Gould at Córdoba, in South America, enumerated 10,649 stars. These marked discrepancies are in a large measure due to the multitude of minute stars that are constantly hovering on the verge of visibility, and which can only be seen by persons gifted with exceptionally good eyesight. With the aid of an opera-glass, thousands of stars can be perceived, and in the fields of large telescopes multitudes of stars are brought within the range of vision.

Early astronomers paid but scant attention to the stars, and scarce anything was known of them. They were called 'fixed' on account of their apparent immobility on the sphere, and consequently served as convenient points from which the motions of planets and of comets could be determined. They, however, did not fail to excite the curiosity of

observers, and conjectures were hazarded as to their nature and origin; but the mystery by which they were surrounded remained impenetrable, and the star-depths could only be contemplated with wonder and awe.

The stars, prior to the overthrow of the Ptolemaic system, were believed to accomplish a diurnal revolution round the Earth; but after the adoption of the Copernican hypothesis, when they were assigned their true position in space, it became evident that the stars were self-luminous orbs, but of what magnitude and how distant no one could tell. When, however, the vast scale upon which the Universe was constructed gradually dawned upon the minds of astronomers, it became evident that the stars must be regarded as orbs rivalling our Sun in splendour, and that their apparent minuteness could be accounted for by their amazing distances.

In 1718 Halley announced that the stars were not 'fixed' but had a real motion in space. He discovered from observations made by himself that Sirius, Arcturus, Aldebaran, and several other bright stars had shifted their positions on the sphere as compared with the places assigned them in Ptolemy's catalogue. This was afterwards verified by J. Cassini. Tobias Meyer in 1756 issued a list of fifty-seven stars, in which he showed the direction and amount of their proper motions based upon observations made by Röemer fifty years previous. Hence, the term 'fixed' could no longer be applied to the stars. Each orb that enters into the formation of the

stellar universe, however distant, is in motion, and pursues a definite path in space, illuminating vast regions, and probably fulfilling its destiny by dispensing light and heat to circling planets.

Towards the close of the eighteenth century a fresh impetus was given to the study of sidereal astronomy by Sir William Herschel, who devoted many years of his life to a minute exploration of the starry heavens. We are indebted to him more than to any other astronomer for our knowledge of the vastness of the stellar universe. It was he who first explored the shining regions of the Milky Way and attempted to delineate its structural configuration. He also penetrated with his great telescopes the recesses of the star-depths, but was unable to fathom their utmost limits. During his exploration of the heavens, Herschel conceived the idea of embracing in one grand harmonius design of celestial architecture all the concourses, systems, and galaxies of stars promiscuously scattered throughout the regions of space. Having this sublime object in view he adopted a method called 'star-gauging,' by which he accomplished an entire survey of the heavens, and examined minutely all the stars in their groups and aggregations as they passed before his eye in the field of the telescope. He sounded the depths of the Milky Way, and in attempting to unravel the intricacies of its structure, perceived clustering swarms of lucid orbs so closely aggregated as to resemble a mosaic of stars. He resolved numerous nebulæ into clusters of stars, and

penetrated with his telescope depth after depth of space occupied by 'island universes of stars,' beyond which he could discern luminous haze and filmy streaks of light, evidence of the existence of other stellar regions still more profoundly situated in the abysmal depths of space. As Herschel extended his survey of the heavens, he found himself incapable of accomplishing the object he had in view, for he discovered that the star-depths were unfathomable; neither could he determine the structural configurations and relationships that existed among the sidereal systems and galactic concourses of stars—the undertaking was too great for human effort. He consequently abandoned his work of star-gauging, and confined his attention to the investigation of other phenomena associated with the stars.

The distances of the stars had for long constituted a problem that astronomers were unable to solve. The stars were known to be inconceivably remote, but how far away no one could tell. In attempting a measurement of the space that intervenes between our Earth and the nearest stars, astronomers had recourse to what is termed 'parallax,' which is the apparent change in the position of an object resulting from a change of the observer's station. The parallactic angle is the measure of the amount of parallax. The stars are so distant that their positions are the same from whatever part of the Earth's surface they are seen, but when observed from opposite points of the Earth's orbit, which affords a base-line of

186 million miles, astronomers equipped with the most delicate and powerful instruments have been enabled to perceive the minutest measurable displacements of a few of the nearest stars.

The first reliable stellar parallax was announced by Bessel in 1840. He found that the star 61 Cygni disclosed a parallax of $0''\cdot3483$, but recent observations have increased it to $0''\cdot45$, a result which indicates a distance 458,000 times that of the Sun from the Earth.

α Centauri, the nearest star to our system, gives a parallax of $0''\cdot75$, a result equivalent to a distance greater by 271,000 times than the 93 million miles that separate the Earth from the Sun. The parallaxes of half a dozen other stars have been determined with comparative exactness, and all indicate extreme remoteness.

Terrestrial measurements are not of much assistance in enabling us to comprehend the distances of the nearest stars. Perhaps the time required by light in travelling such vast intervals of space will give a clearer conception of the remoteness of those orbs. Light, which travels 186,000 miles in every second of time, requires a period of $4\frac{1}{4}$ years to cross the abyss that separates us from the nearest star, and in the case of 61 Cygni the light-unit is $7\frac{1}{4}$ years. The 'light-years' of some of the more conspicuous stars are as follows: Aldebaran, 6 years; Sirius, 8; Procyon, 12; Vega, 18; Capella, 30; Regulus, 35; and Polaris, 42 years. The light from stars of the sixth magnitude, which are just visible to the naked

eye, requires a period of upwards of 100 years to reach the Earth, whilst light emitted by the smallest stars visible in great telescopes does not accomplish its journey until after the lapse of several thousand years.

Entering into the structure of the stellar universe are single stars, double stars, triple, quadruple, and multiple stars; periodical, temporary, and variable stars; star-groups, star-clusters, galaxies, and nebulæ resolvable into stars.

SINGLE or INSULATED STARS are orbs sufficiently isolated in space so as not to be perceptibly influenced by the attraction of other similar bodies. The Sun is an example of this class of star, and is one of a rather widely scattered group situated in the plane of the Milky Way, in or near its centre. As a star among the stars, the Sun would be included in the constellation of the Centaur, *α* Centauri being his nearest neighbour. Stars of this class are believed to be the centres of planetary systems, similar to that of which our Sun is the centre. Reasoning from analogy, we should naturally conclude that there are other suns, numberless beyond conception, the centres of systems of revolving worlds to which they dispense light and heat.

DOUBLE STARS.—Many stars which appear single to the naked eye are found on telescopic examination to be double, i.e. they consist of two stars in juxtaposition. Double stars are divided into two well-defined classes: (1) 'Optical' doubles—stars almost in the same line of vision, and although

apparently very near, are yet situated far apart, and have no physical relationship; (2) *Binary Stars* —these, on the other hand, besides being in close proximity, are united in a mutual bond of union, and revolve round each other, forming real dual systems, the components of which perform their orbital motions in obedience to the law of universal gravitation. We are indebted to Sir William Herschel for the discovery of binary star systems. They are now known to exist in profusion all over the heavens.

The revolution of two suns in one sphere presents to our observation a scheme of creative design of a higher and more complex order in the ascending scale of celestial architecture than that of the single star system with which we are familiar. For, if we assume that round each sun there circles a retinue of planetary worlds, it is obvious that there must exist a more intricate arrangement of the orbs which enter into the formation of such a system than is found among the bodies that gravitate round our Sun.

The common centre of gravity of a binary system is situated on a straight line between both stars, and distant from each in inverse proportion to their respective masses. When the stars are of equal mass, their orbits are of equal dimensions, but when the mass of one star exceeds that of the other, the orbit of the larger star is proportionately diminished as compared with the circumference traversed by the smaller star. When their orbits are circular—

a rare occurrence—both stars pursue each other in the same path and invariably occupy it at diametrically opposite points, nor is it possible for one star to approach the other by the minutest interval of space in any duration of time so long as the synchronous harmony of their revolution remains undisturbed. When a pair of suns move in an

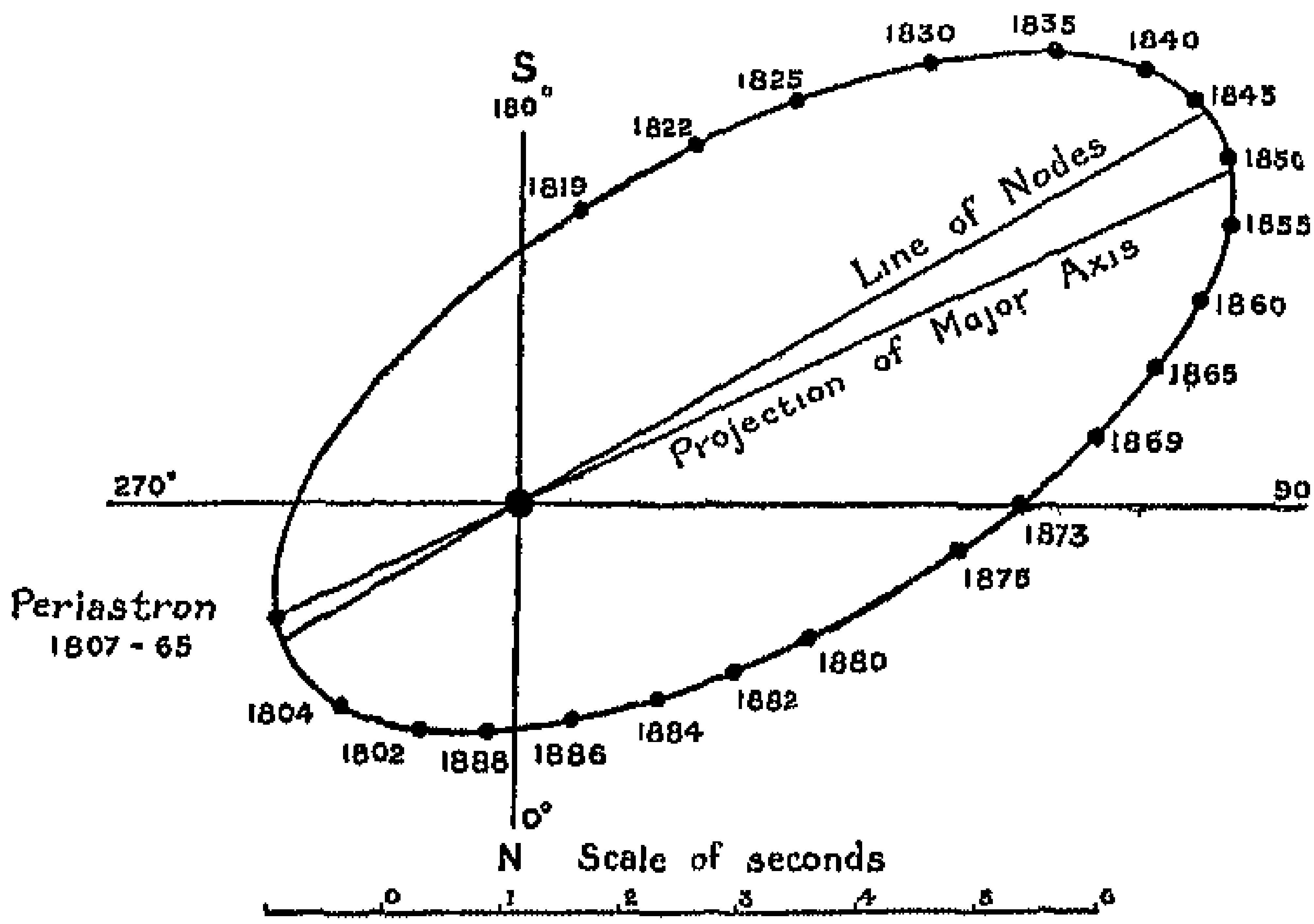


FIG. 5.—A Binary Star System—70 Ophiuchi.
(Drawn by Mr J. E. Gore)
Showing positions of companion star in different years.

ellipse, their orbits intersect, and are of equal dimensions when the stars are of equal mass, their common centre of gravity being then at a point equidistant from each; consequently neither star can approach or recede from this point without the other affecting a similar motion; they must be in periastron, and at apastron together, and any acceleration or retardation of speed must occur simultaneously with each. Stars of unequal magnitude always maintain

a proportionate distance from their common focus, and both simultaneously occupy corresponding parts of their orbits.

The star 70 Ophiuchi may be regarded as typical of a binary system. The components are of the fourth and sixth magnitudes, and are five seconds apart. Their light period is stated to be twenty years, and the combined mass of the system is nearly three times that of the Sun. The pair travel in an orbit from fourteen to forty-two times the radius of the Earth's orbit, so that when in apastron they are three times the distance from each other that they are when in periastron. They accomplish a revolution in eighty-eight years.

The accompanying diagram is a delineation of the beautiful orbits of the components of γ Virginis, which may be described as elongated ellipses. Both stars are of equal mass; consequently their orbits are of equal dimensions, and their common centre of gravity is at a point equidistant from each. Any approach to, or recession from, this point must occur simultaneously with each; they must always

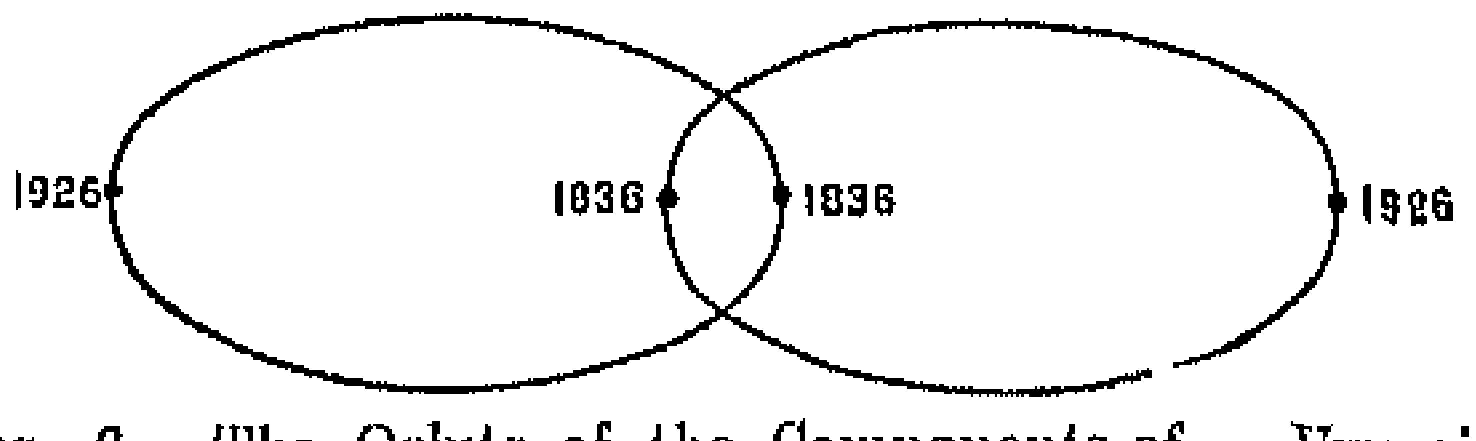


FIG. 6.—The Orbits of the Components of γ Virginis.

occupy corresponding parts of their orbits; the two must be in periastron, and retire together towards apastron.

The ellipse described by this pair is the most

eccentric of known binary orbits, and approaches in form the path pursued by Encke's comet round the Sun. The stars complete a revolution in one hundred and eighty years.

The finest binary star in the northern heavens is Castor, the brighter of the two leading stars in the constellation Gemini. The components are of the second and third magnitudes, and of a brilliant white colour. It is among double stars that the richest and most varied colours predominate. Albireo, in the constellation Cygnus, is one of the loveliest of double stars; the larger component is of a golden yellow colour, the smaller of a sapphire blue. Cor Caroli, in Canes Venatici, is a pleasing double star, the components being of a pale white and lilac colour. Mirac, in Boötes, is a delicate object of charming appearance, the components of which are orange and pale green.

The aid of a good telescope is, however, essential in order that we may be able to perceive the varied colours and tints of the sparkling gems with which Nature has adorned her star-built edifice of the Universe. Most of the precious stones on Earth have their counterparts in the heavens, presenting in a jewelled form, pleasing harmonies, contrasts of colour, and endless variety of shade. The diamond, sapphire, emerald, amethyst, topaz, and ruby sparkle among crowds of stars of more sombre hue. Agate, chalcedony, onyx, opal, beryl, lapis-lazuli, and aquamarine are represented by the radiant sheen emanating from distant suns, displaying an inexhaustible

variety of colour blended in tints of untold harmonics. There are pairs of white, yellow, orange, and red stars; yellow and blue; yellow and pale emerald; yellow and rose-red; yellow and fawn; green and gold; azure and crimson; golden and azure; orange and emerald; orange and lilac; orange and purple; orañge and green; white and lilac; lilac and dark purple. Companion stars revolve round their primaries coloured olive, russet, buff, grey, dun, and other shades indistinguishable by any name.

TRIPLE, QUADRUPLE, and MULTIPLE STARS.—These, when observed with the naked eye, appear as single stars, but when examined with a high magnifying power, each lucid point can be resolved into several component stars. They vary in number from three to half a dozen or more, and form systems of a more complex character than those which have been already described. In the usual construction of a triple system, the secondary star of a binary is resolved into two; each star being in mutual revolution whilst they both gravitate round their primary. By another arrangement, a close pair control the movements of a distant attendant.

One of the most interesting of triple stars is the tri-coloured γ Andromedæ. The brilliant components of this system have their counterparts in the topaz, the emerald, and the sapphire. The larger star is of the third magnitude, and of a golden yellow colour; the secondary of the fifth magnitude and of an emerald green. In 1842 Struve discovered that the companion star is itself double, and that round it there

gravitates a sapphire sun. If in association with these orbs there should circle systems of dependent worlds inhabited by intelligent beings, the varied effect created by light emanating from suns so differently coloured would be exceedingly pleasing and very beautiful. Quadruple stars are usually arranged in pairs, i.e. the primary and secondary of a binary system are each resolvable into two, forming two pairs; each pair being in mutual revolution, whilst they both travel round their common centre of gravity. Close upon twenty of these double double systems are known to astronomers. Ascending higher in the scale of celestial architecture, we come to multiple stars, which form systems still more elaborate and complex, and these, as they increase in number, gradually merge into star-clusters.

If we assume that around each of the components of a multiple star there circles a retinue of planetary worlds, we are confronted with a most perplexing problem as to how the dynamical stability of a system so different from, and so vastly more complicated than, that of our solar system is maintained —where, as it were, suns and planets intermingle— how numerous circling orbs can accomplish their revolutions without being swayed and deflected from their paths by the gravitational attraction of adjacent members of the same systems. Perplexing though the arrangement of such a scheme may be to our conception, yet, each orb has been weighed, poised, and adjusted by Infinite Wisdom to perform its intricate motions in synchronous harmony with

other members of the system—all moving in concerted unison like the parts of a complicated piece of mechanism, and maintained in stable equilibrium by their mutual attraction—

> Mystical dance, which yonder starry sphere
> Of planets and of fixed in all her wheels
> Resembles nearest; mazes intricate,
> Eccentric, intervolved, yet regular
> Then most, when most irregular they seem;
> And in their motions harmony divine
> *So smooths her charming tones that God's own ear*
> Listens delighted.—v. 620–27.

All the natural phenomena with which we are familiar on Earth would, in the case of planets revolving round the component suns of a multiple star system, be of a different kind or altogether absent. Instead of being illumined by one sun, those worlds would, at certain times, have several suns—some more distant than others—above their horizons, and upon very rare occasions, if ever, would there be an entire absence of all of them from their skies. Consequently there would be no year such as we are familiar with; no regular sequence of seasons similar to what is experienced on Earth; no alternation of day and night, for there would be *no night there*, though, in the absence of the primary orb, the light emitted by distant suns, whilst sufficient to banish night, and beyond comparison brighter than the Moon when full, would, in the diminution of its intensity, be as grateful a change as that of from day to night experienced by dwellers on Earth. Should these orbs be differently coloured, each

emitting its own particular shade of light as it appears above the horizon, the varying aspects of the perpetual day enjoyed by the inhabitants of the worlds to which they minister would be of a delightful nature and exceedingly beautiful.

Periodical and Variable Stars.—These are distinguished from other similar objects by fluctuations in their light. The decrease in luminosity of some stars of this class is so apparent, that in the course of a few weeks or months they sink from the position of first or second magnitude stars to invisibility, and after remaining in this state for a certain time re-appear and gradually regain their original brightness. When these fluctuations of light recur with regularity, the stars are called 'periodical'; when the recurrence is uncertain and irregular they are described as 'variable.' Some stars accomplish their cycle of changes in a few days, many in a few weeks or months, and others not until the expiration of many years. Algol, 'the Demon,' situated in Perseus, is one of the most interesting of periodical stars, its fluctuations being perceptible to the naked eye. For about two days and thirteen hours it shines as a star of the second magnitude, then in three and a half hours it declines to the fourth magnitude, and remains thus for twenty minutes. On the expiration of this short interval, it begins to increase, and in three and a half hours more, regains its original brilliancy, at which it remains for two days and thirteen hours, afterwards to undergo a similar series of changes.

Mira, 'the Wonderful,' situated in the constellation Cetus, is one of the most remarkable of periodical stars. When at its maximum brilliancy it shines for a fortnight as a star of the second magnitude. It then begins to decline, and at the end of three months becomes invisible. It remains in this condition for about five months, when it re-appears, and during the ensuing three months gradually regains its former brightness. Mira completes a cycle of its changes in about three hundred and thirty-one days, during which time it oscillates between a star of the second and tenth magnitudes.

No explanation is forthcoming which would satisfactorily account for the phenomena associated with long-period variable stars, but in the case of short-period stars of the Algol type, it is believed that a close dark companion or satellite revolves round its primary, and that at recurring intervals it passes between the Earth and the star, thus intercepting a portion of its light and causing an apparent diminution of the orb. The existence of Algol's dark satellite has been verified.

TEMPORARY STARS.—The stars have been regarded from *time immemorial* as *the embodiment of* all that is eternal and unchangeable. From age to age they present the same appearance, shine with the same undiminished splendour, and rise and set with the same regularity. Yet, the serenity of the heavens does not always remain undisturbed, for on rare occasions, a 'nova' or new star unexpectedly blazes forth and perplexes astronomers—and after

shining vividly for a few weeks or months, gradually diminishes in size and brightness until it ceases to be visible.

A record has been kept of about twenty temporary stars that have been observed since the publication of reliable data. Pliny (134 B.C.) mentions the appearance of a new star in Scorpio, and it is said *that it was the apparition of this star that led the* famous astronomer Hipparchus to construct what is known as the earliest star-catalogue. In the reign of the Emperor Honorius (A.D. 389) a new star appeared in Aquila, which surpassed Venus in magnitude. In 827 a new star of considerable brilliancy was seen at Babylon, which remained visible for four months. A 'nova' appeared in Aries in 1012, and one in Ophiuchus in 1230. But the most notable object of this class was the star observed by Tycho Brahé in Cassiopeia. It first attracted his attention in November 1572, and when at its brightest rivalled Venus. It remained visible for sixteen months, and finally disappeared in March 1574. Anthelme, a Carthusian monk, discovered a new star in Cygnus in 1670; another was seen in Ophiuchus in 1848; one in Scorpio in 1860; in Corona Borealis in 1866; in Andromeda in 1885; and in Auriga in 1892.

Astronomers can only conjecture as to what may be the causes that give origin to these short-lived stars.

STAR-GROUPS.—These are plentifully distributed over the heavens, and by their conspicuousness enhance the beauty of the nocturnal sky. The

seven stars in *Ursa Major*, *the crown in Corona* Borealis, the belt in Orion, the sickle in Leo, and the Hyades in Taurus are well known to all observers. The stars in Coma Berenices form a rich group, and those in Aquila, Cassiopeia, Cygnus, and other constellations have each their attractive aspects.

STAR-CLUSTERS.—Clusters have been divided into two classes—'irregular' and 'globular,' but no sharp line of demarcation exists between them, though each class has its distinctive appearances. Upwards of five hundred clusters are known to astronomers, the majority of which are exceedingly remote. Many of them contain thousands of stars compressed into a very small space, whilst others are so distant that the largest telescopes are incapable of resolving their nebulous appearance into stars.

IRREGULAR CLUSTERS are of different shapes and sizes. They present no distinct outline, possess no structural arrangement, and are not condensed towards *their centre, but are promiscuously aggregated after* the manner of a flock of birds. The three most conspicuous clusters of this class visible in the northern heavens are the Pleiades in Taurus, the Great Cluster in the sword-handle of Perseus, and Praesepe in Cancer, commonly called the Beehive.

GLOBULAR CLUSTERS have been described by Sir John Herschel as 'the most magnificent objects that can be seen in the heavens.' They are all very remote, and when viewed with a telescope present the appearance of a ball of stars. In some clusters the constituent stars are perceptible as minute points of light;

in others more distant they appear as coarse granules, and in those still more remote, resemble a 'heap of golden sand.' Many clusters are situated at such a profound distance in space that astronomers with the most powerful telescopes are unable to define their stellar structure.

Globular clusters usually present a radiated appearance at their circumference, but become more condensed towards the centre, where there seems to exist the resemblance of a nucleus. This apparent condensation is not altogether owing to the depth of star-strata as viewed from the circumference of the cluster, but there would seem to be present an attractive force, probably gravitational, which draws the stars towards its centre, and if this 'clustering power' were not opposed by some other counter-acting force, the stars would eventually coalesce into one mass. It is not known how the dynamical equilibrium of a star-cluster is maintained, for, on *account of its extreme remoteness, no perceptible* motion can be observed among its component stars, whether towards concentration or diffusion. The laws by which these stellar aggregations are produced and governed are wrapped in deep mystery.

The largest and most magnificent globular cluster in the heavens is situated in the constellation of the Centaur, in the southern hemisphere. To the naked eye it is visible as a round, indistinct, cometary object, but when observed with a powerful telescope it expands into a large globe of innumerable minute stars of the fifteenth and sixteenth magnitudes.

GREAT CLUSTER IN HERCULES

Sir John Herschel describes it as 'the richest and largest object of its kind in the heavens.' Another remarkable cluster in Toucan is described by Herschel as being 'most magnificent; very large, very bright, and very much compressed in the middle.' The interior mass consists of closely aggregated pale rose-coloured stars, surrounded by others of a pure white, which constitute the remainder of the cluster. A fine globular cluster is situated in Sagittarius, between the archer's head and the bow; and in Aquarius there is a magnificent spherical ball of stars which Sir John Herschel compared to a heap of fine sand.

The finest and most remarkable object of this class visible in the northern heavens is the Great Cluster in Hercules. It was discovered by Halley in 1714. He writes: 'This is but a little patch, but it shows itself to the naked eye when the sky is serene and the Moon absent.' When observed with a powerful telescope, its magnificence becomes at once apparent to the beholder. 'Perhaps,' says Dr. Nichol, 'no one ever saw it for the first time through a telescope without uttering a shout of wonder.' At the circumference of the cluster the stars are rather scattered, but towards its centre they appear so closely aggregated that their combined effulgence gives rise to a perfect blaze of light. Sir William Herschel estimated that there are 14,000 stars in the cluster, but as a result of more recent investigations this number has been considerably reduced, and it is now generally believed that not

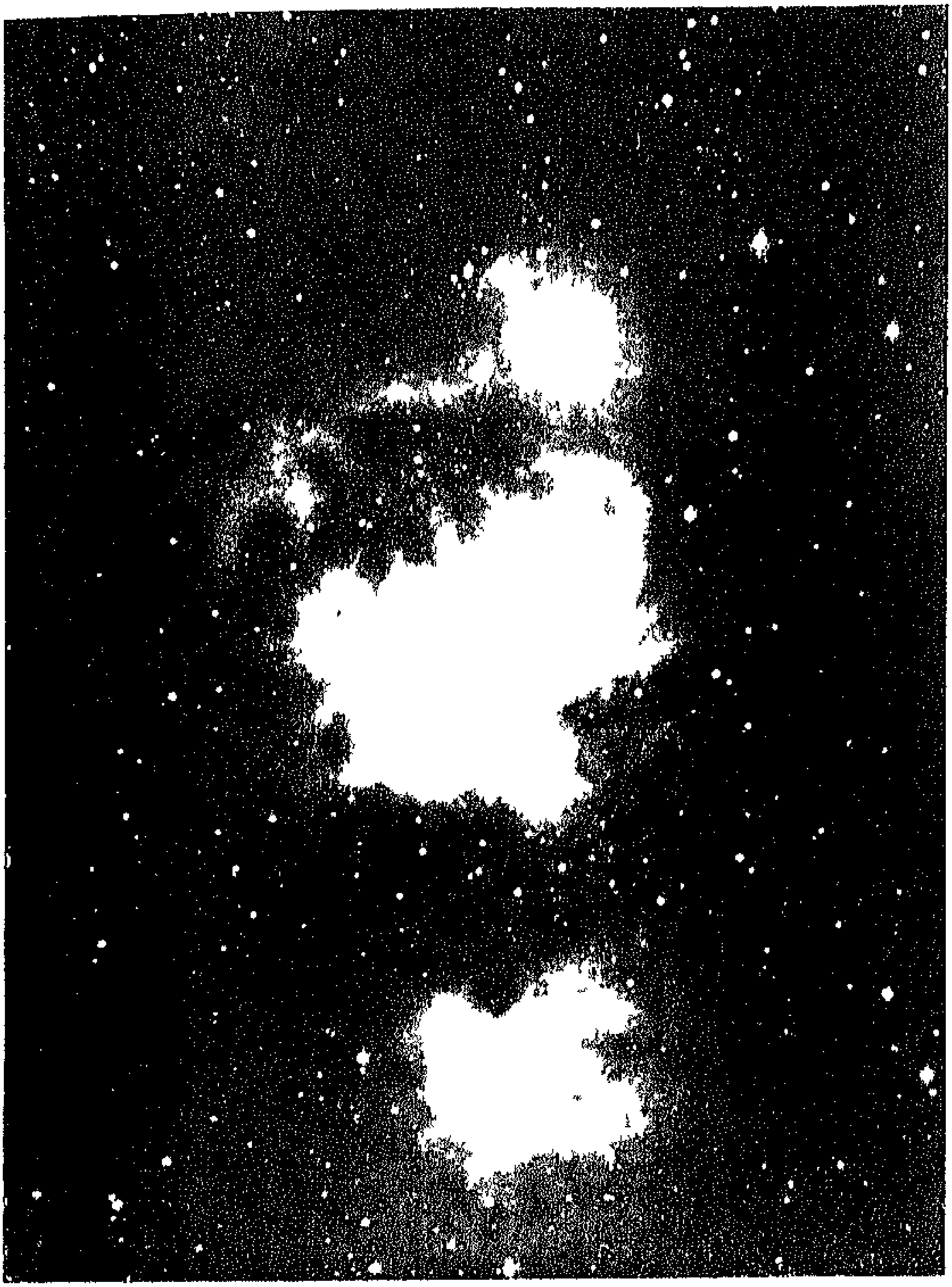
more than 4000 stars enter into the formation of this superb object.

For what purpose do these thousands of clustering orbs shine? Who can tell? Night is unknown in the regions illumined by their brilliant radiance. This stupendous aggregation of suns testifies to the magnificence of the starry heavens, and to the omnipotence of the Creator.

GALAXIES.—These consist of immense concourses of stars, which form separate 'island universes' floating in the depths of space. The Milky Way, to which our system belongs, and the Magellanic Clouds in the southern hemisphere, are examples of these vast stellar aggregations.

NEBULÆ.—We now reach the last, and what are believed to be the most distant, of the known contents of the heavens. They are all exceedingly remote, faintly luminous, devoid of any perceptible motion, and in the majority of instances are only visible in large telescopes. Some nebulæ have been resolved into star-clusters, but many exhibit no stellar structure.

The Great Nebula in Orion is the largest and most remarkable of the nebulæ. It is perceptible to the naked eye, and when viewed with a glass of low magnifying power, appears as a luminous haze surrounding the multiple star θ Orionis, one of the stars in the giant's sword. When observed with a powerful telescope, this nebula is perceived to be of vast dimensions. Its brightest part, which is of a greenish tinge, bears a slight resemblance to



GREAT NEBULA IN ORION

the wing of a bird; projecting outward from the parent mass are streams, branches, sprays, filaments and curved spiral wreaths of nebulous matter that occupy an area of the heavens measuring 4° by $5\frac{1}{2}$°.

This object remained for long a profound mystery; no telescope was capable of resolving it, nor was its nature ascertained until the spectroscope revealed that this '*unformed fiery mist, the chaotic material of future suns*,' consists of a stupendous aggregation of luminous gases—hydrogen, helium, and other elementary substances that pervade a region of space greater in extent than that occupied by the entire stellar system to which our Sun belongs.

In the days when Milton lived—three hundred years ago—the nocturnal aspect of the heavens was precisely similar to what it now is. The stars pursued their identical paths, and looked down upon the Earth with the same tranquil gaze, regardless of the vicissitudes that affect the denizens of this terrestrial sphere. The constellations that adorn the celestial *vault duly appeared in their seasons*—

> and in the ascending scale
> Of Heaven the stars that usher evening rose.
>
> iv. 354-55.

The winter glories of Orion, the scintillating brilliancy of Sirius, the stately march of Arcturus, the joyous dance of the Pleiades, together with other orbs that illumine the firmament, commanded then, as now, the admiration of all beholders.

With these attractive aspects of the midnight sky Milton was entirely familiar, and his allusions

to them in his poems are both frequent and full. But if we endeavour to ascertain his views with respect to the distances, magnitudes, and constitution of the stars, we shall find that he remains silent; apparently those details had not occupied his thoughts, nor had it dawned upon his mind that the stars were the light- and heat-giving centres of other systems of worlds. This need occasion no surprise when we consider how little was known of the stars in Milton's time. Even astronomers had their doubts about them. Tycho Brahé would not admit the supposition that the stars were comparable to our Sun, and believed that their distances did not much exceed those of the planets. Kepler sagaciously surmised that the distance of the stars was about two thousand times that of Saturn from the Sun, but it has been ascertained that the remoteness of the nearest star exceeds Kepler's estimate by about fourteen times. Galileo remarked that the stars were not illumined by the Sun's rays in the same manner as were the planets, but expressed no opinion as to their magnitude and physical constitution. Only within the past fifty years has conclusive evidence been obtained as to the real nature of the stars. By the spectroscopic analysis of their light, proof was forthcoming that the elements of which they consist are in almost every respect identical with, and exist under, conditions similar to those that prevail in the Sun. The stars, therefore, are suns, many of them surpassing in brilliance and magnitude the great luminary of our system.

The subordinate position assigned to the stars by Ptolemaic astronomers becomes apparent on observing how Milton, in various passages, refers to them. The archangel Uriel, who witnessed the Creation, describes how the stars came into existence (iii. 708–21). After having mentioned the four grosser elements that combined to form the terrestrial globe, he states that a fifth element, the 'ethereal quintessence of Heaven,' usually called the 'ether,' in its upward flight rolled orbicular, and turned to stars numberless.

The poet says that God, having created the Sun—

> then formed the Moon
> Globose, and every magnitude of stars,
> And sowed with stars the heaven thick as a field.
> vii. 356–58.

And again, God—

> made the stars,
> And set them in the firmament of heaven,
> To illuminate the Earth, and rule the day
> In their vicissitude, and rule the night,
> And light from darkness to divide.—vii. 348–52.

The insignificance of the stars when compared with the surpassing splendour of the Sun is very apparent to any casual observer of the heavens whose knowledge of those orbs is limited to the visual impression which they create. Milton appears to have regarded the stars in this light, both individually and collectively, when referring to the Sun:

> where the great luminary,
> Aloof the vulgar constellations thick,
> That from his lordly eye keep distance due,
> Dispenses light from far.—iii. 576–79.

In Milton's lifetime, scarce anything was known of the stars, and it was not until more than a century later, when Herschel, with his powerful telescopes, 'burst the barriers of heaven,' that the glories of the sidereal universe were revealed.

In summing up Milton's knowledge of the stars, we should not greatly err in concluding (1) that when compared with the Sun and Moon he regarded them as objects of small magnitude, (2) that they were more distant than the planets, but not very remote, (3) that they occupied a circumscribed region in space, (4) that they were innumerable.

Milton acquiesced in the popular belief as to the countless number of the stars perceptible to the naked eye. In alluding to the visible presence of the Deity the poet says :

> About him all the Sanctities of Heaven
> Stood thick as stars.—iii. 60–1.

and in describing the Powers of Satan that were *advancing with winged speed*, he calls them—

> an host
> Innumerable as the stars of night.—v. 744–45.

Satan, prior to his fall, is described as—

> brighter once midst the host
> Of Angels than that star the stars among.—vii. 132–33.

Although Milton's poems contain numerous allusions to the stars, yet no individual orb is mentioned in them by name. But two stars well known to astronomers are indirectly referred to by the poet, viz. Sirius, the great dog-star, and Alpha Arietis, the leading star in the constellation Aries.

Milton designates Sirius the 'swart-star'—the star associated with the oppressive heat of summer. In describing the flowery contents of low sequestered valleys—

> On whose fresh lap the swart[2] star sparely looks.—L. 138.

the poet alludes to the solstitial heat experienced during the dog-days or *dies caniculares*, a period that lasted for twenty days before, and twenty days after the heliacal rising of Sirius, i.e. its earliest appearance in the morning before sunrise. During this time unwholesome exhalations were believed to permeate the atmosphere, which caused sickness among men and madness in dogs. Homer alludes to the orb—

> whose burning breath
> Taints the red air with fevers, plagues and death.

Sirius, the brightest star in the heavens, and leader of the stellar host, is situated in Canis Major—one of Orion's hunting dogs. The orb greatly surpasses our Sun in magnitude and in luminosity. According to recent photometric measurements, Sirius emits from sixty to seventy times the quantity of light given out by the Sun, and exceeds him in mass two and a half times. At the distance of Sirius (fifty billion miles), our Sun would shrink to the dimensions of a third magnitude star, and the combined light of sixty-three such stars would only equal the brilliant radiance of the great dog-star.

[2] The use here is appropriate, because strictly the word signifies 'darkened by heat,' and that, Milton implies, is what the flowers would be after the dog-star had 'looked' on them.—A. W. Verity.

The Egyptians worshipped the orb as 'Sothis,' and it was believed to be the bright abode of the soul of Isis. The nations that inhabited the region of the Nile commenced their year with the heliacal rising of Sirius; its appearance above the horizon having been regarded as a sure forerunner of the rising of the great river, the fertilising flood of which was attributed to the influence of this beautiful star. The name Mazzaroth, in Job, applies to this brilliant orb. Homer compares the fiery lustre of Diomede's armour to the flashing splendour of the great dog-star. Among the Romans, Sirius was regarded as a star of evil omen, and its visibility after the summer solstice was associated with pestilence and miasmatic diseases.

Alpha Arietis, 'the fleecy star that bears Andromeda,' although of the second magnitude, is yet of some importance to astronomers. It is from the First Point of Aries that the Right Ascension of a heavenly body—a measurement equivalent to terrestrial longitude—is counted on the equator. In the time of Hipparchus, the *ecliptic* intersected the celestial equator in Aries when the vernal equinox occurred, and with it the commencement of the astronomical year. The star was called Hamal (a Sheep), by the Arabs, and the constellation Aries (the Ram) is represented as looking backward. Manilius writes:

> First Aries glorious in his golden wool,
> Looks back and wonders at the mighty Bull.

Aries is associated with the legend of the Golden

Fleece, in quest of which Jason, with his valiant crew, sailed in the good ship Argo. Milton's reference to this particular star indicates that he studied astronomy as a science, and fully recognised the astronomical importance of the First Point of Aries.

Milton on two occasions alludes to the Sun as a star:

> So sinks the day-star in the ocean bed,
> And yet anon repairs his drooping head,
> And tricks his beams, and with new-spangled ore
> Flames in the forehead of the morning sky.—L. 168–71.

And again:

> ere this diurnal star
> Leave cold the night.—x. 1069–70.

Lucifer, or the morning star, was commonly known as the day-star—the star that ushers in the day. Ben Jonson, who was contemporary with Milton, writes:

> I meant the day-star should not brighter rise.

But, in both of the above citations it is apparent that Milton's utterances apply to the Sun, and although poetical, they yet give a correct definition of the orb and of his office—the star that illumines and warms the Earth—the star that, by its proximity, gives us the day.

In 'Comus' the Spirit says:

> Come, let us haste; the stars grow high.—C. 956.

Sidereal astronomy was in its infancy when Milton lived, and of the physical constitution of the stars

nothing was known. But this lack of knowledge did not retard the poet from making free use of his observational powers, in the exercise of which he has given us so many beautiful descriptions of the stellar regions, and of the orbs that occupy them.

CHAPTER VII

MILTON'S REFERENCES TO FAMILIAR CELESTIAL OBJECTS

THE PLANET HESPERUS

THIS is the beautiful Morning and Evening Star; the peerless planet that ushers in the twilight and the dawn; the harbinger of day, and unrivalled queen of the evening. Venus, called after the Roman goddess of love, and also identified with the Greek Aphrodite of ideal beauty, is the name by which the planet is popularly known, but Milton does not so designate it. By the Ancients, the orb was called Lucifer and Phosphor when it shone as a morning star before sunrise, and Hesperus and Vesper when it became visible after sunset as the evening star. It is the most lustrous of all the planets, and at certain periods its brilliancy is so marked as to cast a distinct shadow.

Venus is the second planet in order of distance from the Sun. Its orbit lies between those of Mercury and the Earth, and in form deviates but slightly from a circle. The distance of Venus from the Sun

is about 67 million miles. The diameter of the planet is 7700 miles, about the same as that of our globe, and its mean density is not much less. It is surrounded by a dense atmosphere. Venus accomplishes a revolution of her orbit in 224 days, and travels with a mean velocity of 80,000 miles an hour, or more than 22 miles in a second. Astronomers are not agreed as to the planet's period of rotation—some say it rotates on its axis in about 24 hours, whilst others maintain that its rotation and revolution synchronise. The planet's axis is nearly perpendicular to the plane of its orbit. Unlike the Earth, Venus has no satellite.

Twice in every revolution Venus is in conjunction with the Sun. In superior conjunction the planet is in the same longitude as the Sun, and has that luminary between it and the Earth. In inferior conjunction the planet is between the Earth and the Sun. At these times the orb is invisible. Venus is a morning star when travelling from inferior to superior conjunction, and an evening star when moving from superior to inferior conjunction. The planet attains her greatest brilliancy at an elongation 40° west or east of the Sun—five weeks before and after inferior conjunction. Her figure then resembles the Moon when five days old, and it is at these periods that she casts a shadow at night. The planet can never be much longer than three hours above the horizon before sunrise and after sunset.

The phases of Venus are similar to those exhibited by the Moon on her monthly journey round the

Earth, and are brought about by a change in position of the illumined hemisphere of the planet with regard to our globe. In superior conjunction the whole enlightened disc of the planet is turned towards the Earth, but is invisible, being lost in the solar rays. Shortly before and after the orb arrives at this point her form is gibbous, the illumined portion being less than a circle, but greater than a semicircle. At her greatest elongation, east or west of the Sun, the planet resembles the Moon in quadrature —a half Moon, and between this phase and inferior conjunction she is visible as a beautiful crescent that becomes narrower and sharper until just before her disappearance at the conjunction, when she resembles a curved luminous thread. After having passed inferior conjunction, when her darkened hemisphere is turned towards the Earth, the planet re-appears on the other side of the Sun as the morning star.

Next to the Sun and Moon, Venus is the brightest object in the heavens. Her maximum brilliancy occurs once in every eight years, when the orb can be seen with the naked eye in full daylight. The intrinsic brilliancy of Sirius is greater than that of Venus, which shines by reflected light, but as an object to gaze upon, the planet easily surpasses in splendour the leader of the stellar host.

Viewed from Venus, the Sun would present a diameter half as large again as when observed from the Earth. Consequently the planet receives twice as much light and heat as does our globe. Venus

possesses a dense and extensive atmosphere in which is contained aqueous vapour. One writer describes the orb as 'doubly swathed in a steaming ocean, and in steaming vapour exhaled by it.' Should vegetation be present, it must be of more than tropical luxuriance nurtured amid such moisture and heat; the planet is probably clothed with a wealth of arboraceous growth and herbage surpassing everything terrestrial of a like nature.

If there is life on Venus, we should expect to find creatures that can live in a moist, torrid heat. A French savant, M. E. Perrier, in the free exercise of his imagination, supported by tolerably reliable deductions, mentions the organisms that may inhabit the planet, and describes their mode of existence. He says:

> Organised life is more than probable: a life that is violent, vigorous, abundant, but less advanced than our own. Butterflies measuring a yard across the wings, and beetles of proportionate size hover over the crests of giant ferns and exaggerated grasses. Mighty frogs croak in the steaming marshes, and are devoured by enormous reptiles. Fish there may be, but fish of the primeval slime, monstrous caricatures of tropical splendour. Neither bird nor mammal has yet appeared.

Although so pleasing an object to gaze upon, Venus, when viewed through the telescope, is a source of disappointment. This is in consequence of her dazzling brilliancy, which renders any accurate definition of her surface impossible. Sir John Herschel writes:

> The intense lustre of its illumined part dazzles the sight, and exaggerates every imperfection of the telescope; yet we see

clearly that its surface is not mottled over with permanent spots like the Moon; we notice in it neither mountains nor shadows, but a uniform brightness in which sometimes we may indeed fancy, or perhaps more than fancy, brighter or obscurer portions, but can seldom or never rest fully satisfied of the fact.

Schröter, a German astronomer, believed that he discerned mountains of lofty elevation on the planet, but his observation has not been confirmed.

Science has so far failed to penetrate the veil of Aphrodite—the 'sheeny robe of cloud' that conceals the planet from the gaze of curious mortals. Much relating to the orb is mere conjecture; and although our nearest planetary neighbour, yet the lustrous shell of cloud which constitutes her environment prevents astronomers from ascertaining any definite information regarding the effulgent orb.

Milton fully appreciated the charming aspect of this peerless orb—the most beautiful and lustrous of the planets upon which men have gazed with longing admiration, and designated the emblem of all beauty and all love. Hesperus and Lucifer are the names by which the planet was known to the poet; he also recognised it as the morning and evening star. In none of his poems does he introduce the name 'Venus' when alluding to the orb; the reputation borne by the licentious goddess among mortals may have influenced the poet—who always extolled virtue and purity—not to associate her name with this beautiful star. In addressing the orb as the morning star, he expresses himself thus:

> Fairest of Stars, last in the trains of night,
> If better thou belong not to the dawn,

> Sure pledge of day, that crown'st the smiling morn
> With thy bright circlet, praise Him in thy sphere
> While day arises, that sweet hour of prime.
> v. 166-70.

Having addressed the planet as 'fairest of stars,' Milton associates with the orb all the charming phenomena that accompany the dawn and the awakening of morn. The illumined veil of Aphrodite flashes out of the dusk and lights the way for radiant Aurora as she unbars the gates of light on her triumphal progress through the skies.

Milton's exquisite song on 'May Morning' commences with a charming allusion to the morning star rejoicing in its course, and accompanied by vernal delights that impart joyousness to the hearts of all who welcome the propitious month of May:

> Now the bright morning star, day's harbinger,
> Comes dancing from the East, and leads with her.
> The flowery May, who from her green lap throws
> The yellow cowslip, and the pale primrose.
> M. M. 1-4.

Lucifer,[1] one of the names by which Satan was known after his expulsion from Heaven, is mentioned in the following citations:

> The rest were all
> Far to the inland retired about the walls
> Of Pandemonium, city and proud seat
> Of Lucifer, so by allusion called
> Of that bright star to Satan paragoned.—x. 422-26.

[1] The name *Lucifer*, 'light bringer,' is properly a Latin title of the morning star, but it was applied by patristic writers to Satan, in allusion, perhaps, to the tradition of the original 'brightness' of his person.—A. W. VERITY.

Elsewhere the poet says of the arch-rebel

> His countenance as the morning star that guides
> The *starry flock, allured them, and with lies*
> Drew after him the third part of Heaven's host.
> v. 708–10.

After his soliloquy in the desert, Milton says of the Saviour:

> So spake our Morning Star then in his rise.—P. L. i. 294.

As Hesperus, and the evening star, the planet is repeatedly introduced by Milton with pleasing effect in his references to expiring day:

> The Sun was sunk, and after him the star
> Of Hesperus, whose office is to bring
> Twilight upon the Earth, short arbiter
> Twixt day and night.—ix. 48-51.

The surpassing brilliance of the orb is alluded to by the poet when he says:

> Hesperus that led
> The starry host rode *brightest*.—iv. 605–6.

The intimate friendship that existed between Milton and the ill-fated Edward King, when they were students at Christ's College, Cambridge, is described by the poet in pastoral verse as that of fellow shepherds who tended the same flock:

> Oft till the star that rose at evening bright,
> Toward Heaven's descent had sloped his westering wheel.
> i. 30–1.

Milton associates Hesperus with hymeneal rejoicing:

> *And now of love they treat, till the evening star,*
> Love's harbinger, appeared.—xi. 588–89.

In describing his nuptials with Eve, Adam says:

> The Earth
> Gave signs of gratulation, and each hill;
> Joyous the birds; fresh gales and gentle airs
> Whispered it to the woods, and from their wings
> Flung rose, flung odours from the spicy shrub,
> Disporting, till the amorous bird of night
> Sung spousal, and bid haste the evening star
> On his hill top to light the bridal lamp.—viii. 513–20.

The phases of Venus were one of Galileo's discoveries with the telescope. They afforded him conclusive evidence that the planet revolved round the Sun.

The Planet Earth [2]

No lovelier planet circles round the Sun than the planet Earth, with her oceans, continents, mountains, valleys, rivers, lakes, and plains. Surrounded by heaven's azure, radiant with the sunlight of her day, and adorned by night with countless sparkling points of gold, this beautiful world, the abode of Man, is of paramount importance to us, and is the only part of the Universe of which we have any direct knowledge.

The Earth is the third planet in order of distance from the Sun, and is situated between the orbits of Venus and Mars. In form, our globe resembles an orange, being slightly flattened at the poles and bulging at the equator. It is therefore not a perfect

[2] Although not a celestial body, it is desirable to describe the Earth as a member of the solar system.

sphere but an oblate spheroid. This figure of the Earth affords strong evidence that our globe assumed its present form whilst rotating rapidly on its axis when in a fluid or plastic state. The Earth's polar or shortest diameter is 7899 miles, and its equatorial or longest diameter 7926 miles—greater than the other by 27 miles, which indicates the extent of the flattening of the Earth at the poles. The circumference of the globe at the equator is 24,899 miles, and its total area is 197 million square miles. The mean density of the Earth is five and a half times greater than that of water.

The Earth rotates from west to east round an imaginary axis, and accomplishes a complete revolution in twenty-four sidereal hours, or, according to solar time, in 23 hours 56 minutes 4 seconds. This movement is sustained with such exact precision that during the past 2000 years it has been impossible to detect the minutest difference in the time in which the globe completes a revolution on its axis. In this motion we have a time-measuring unit which may be regarded as absolutely correct. The extremities of the Earth's axis are termed the north and south poles. They are always directed to the same point in the heavens. Equidistant from the poles is the great circle called the equator, which divides the globe into two equal hemispheres.

The mean distance of the Earth from the Sun is about 93 million miles. Our globe is nearer the orb by 3¼ million miles at Christmas than at midsummer—a difference which indicates the extent of

the eccentricity of her orbit. The Earth completes a revolution round the Sun in 365 days 6 hours 9 minutes. In this interval she travels 580 million miles with an average velocity of 66,000 miles an hour or 18½ miles a second. The Earth performs none of her motions with rigid precision, they being subject to slight irregularities called *perturbations* that are caused by the gravitational attraction of other members of the solar system.

The Earth, if viewed with a telescope from Venus or from the Moon, would exhibit but few topographical details, as the proportion of light sent back into space after reflection from the terrestrial surface is very small, most of it being absorbed or scattered in the atmosphere. The presence of several lofty mountain-ranges, such as the Andes and Himalayas, could be discerned, and more than a dozen snow-clad peaks would be visible, but no evidence would be forthcoming to indicate the existence of the teeming organic life that abounds on the surface of mother Earth.

The spot on Earth round which centres the chief interest in Milton's great poem is Paradise, which was situated eastward in Eden—a district of Western Asia. It was here where God ordained that Man should first dwell—a place created for his enjoyment and delight.

After his soliloquy on Mount Niphates, Satan pursues his way to Paradise, and arrives in Eden, where he beholds at a distance the Happy Garden :

So on he fares, and to the border comes
Of Eden, where delicious Paradise,
Now nearer, crowns with her enclosure green,
As with a rural mound, the champain head
Of a steep wilderness, whose hairy sides
With thicket overgrown, grotesque and wild,
Access denied; and overhead up-grew
Insuperable highth of loftiest shade,
Cedar, and pine, and fir, and branching palm,
A sylvan scene, and as the ranks ascend,
Shade above shade, a woody theatre
Of stateliest view. Yet higher than their tops
The verdurous wall of Paradise up-sprung;
Which to our general sire gave prospect large
Into his nether empire neighbouring round.
And higher than that wall, a circling row
Of goodliest trees, loaden with fairest fruit,
Blossoms and fruits at once of golden hue
Appeared, with gay enamelled colours mixed;
On which the Sun more glad impressed his beams
Than in fair evening cloud, or humid bow,
When God hath showered the Earth; so lovely seemed
That landskip. And of pure now purer air
Meets his approach, and to the heart inspires
Vernal delight and joy, able to drive
All sadness but despair. Now gentle gales,
Fanning their odoriferous wings, dispense
Native perfumes, and whisper whence they stole
Those balmy spoils. As when to them who sail
Beyond the Cape of Hope, and now are past
Mozambic, off at sea north-east winds blow
Sabean odours from the spicy shore
Of Araby the Blest; with such delay
Well pleased they slack their course, and many a league
Cheered with the grateful smell, old Ocean smiles.
iv. 131–65.

In gaining access to the Garden, Satan, with one slight bound, overleaped the tangled thicket of shrubs and brushwood that formed an impenetrable

barrier, and having alighted within, flew up on to the Tree of Life:

Beneath him, with new wonder, now he views,
To all delight of human sense exposed,
In narrow room Nature's whole wealth; yea more!—
A Heaven on Earth: for blissful Paradise
Of God the garden was, by Him in the east
Of Eden planted. Eden stretched her line
From Auran eastward to the royal towers
Of great Selucia, built by Grecian kings,
Or where the sons of Eden long before
Dwelt in Telassar. In this pleasant soil
His far more pleasant garden God ordained,
Out of the fertile ground he caused to grow
All trees of noblest kinds for sight, smell, taste;
And all amid them stood the Tree of Life
High eminent, blooming ambrosial fruit
Of vegetable gold: and next to life,
Our death, the Tree of Knowledge, grew fast by—
Knowledge of good, bought dear by knowing ill.
Southward through Eden went a river large,
Nor changed his course, but through the shaggy hill
Passed underneath ingulfed; for God had thrown
That mountain, as his garden mould, high raised
Upon that rapid current, which, through veins
Of porous earth with kindly thirst up-drawn,
Rose a fresh fountain, and with many a rill
Watered the garden; thence united fell
Down the steep glade, and met the nether flood,
Which from his darksome passage now appears;
And now, divided into four main streams,
Runs diverse, wandering many a famous realm
And country whereof here needs no account;
But rather to tell how, if Art could tell
How, from that sapphire fount the crispèd brooks,
Rolling on orient pearl and sands of gold,
With mazy error under pendent shades
Ran nectar, visiting each plant, and fed
Flowers worthy of Paradise, which not nice Art

In beds and curious knots, but Nature boon
Poured forth profuse on hill, and dale, and plain,
Both where the morning Sun first warmly smote
The open field, and where the unpierced shade
Imbrowned the noontide bowers.—iv. 205-46.

Milton's description of Paradise is not less remarkable than is his portrayal of the lurid scenes and horrors of Pandemonium. The versatility of his poetic genius is nowhere more apparent than in the charming pastoral verse contained in this part of his poem. The poet has lavished the whole wealth of his luxuriant imagination in his description of Eden and blissful Paradise, with its 'vernal airs' and 'gentle gales'; its 'verdant meads' and 'murmuring streams rolling on orient pearl and sands of gold'; its 'stately trees laden with blossom and fruit'; its spicy groves and shady bowers, over which there breathed the eternal Spring.

Satan, in an eloquent apostrophe to the primitive Earth, testifies to her consummate loveliness as she appeared fresh from the hands of the Creator; he also glorifies her supremacy over the other orbs of the firmament that minister to her requirements:

O Earth how like to Heaven, if not preferred
More justly seat worthier of gods, as built
With second thoughts, reforming what was old!
For what God, after better, worse would build?
Terrestrial Heaven, danced around by other Heavens
That shine, yet bear their bright officious lamps,
Light above light, for thee alone, as seems,
In thee concentrating all their precious beams
Of sacred influence! As God in Heaven
Is centre, yet extends to all, so thou

> Centring receiv'st from all those orbs; in thee,
> Not in themselves, all their known virtue appears,
> Productive in herb, plant, and nobler birth
> Of creatures animate with gradual life
> Of growth, sense, reason, all summed up in Man,
> With what delight could I have walked thee round,
> If I could joy in aught—sweet interchange
> Of hill and valley, rivers, woods, and plains,
> Now land, now sea, and shores with forest crowned,
> Rocks, dens, and caves.—ix. 99–118.

In this exquisite passage, the adaptability of the Ptolemaic system to poetic description is beautifully exemplified by Milton.

As a habitable world, the Earth is perhaps the most important of the planets. It is the largest of the terrestrial planets, the other three, viz. Mercury, Venus, and Mars, being inferior to it in size. Our globe is also specifically the heaviest of all the planets. Mercury and Venus possess no satellite; Mars has two diminutive moons, each not much more than ten miles in diameter; but the Earth has in attendance upon her *a satellite which, in proportion to the size* of its primary, exceeds in magnitude all the other satellites of the system. The four great outer planets, viz. Jupiter, Saturn, Uranus, and Neptune, are on an immensely larger scale than those whose names have been mentioned, but their physical condition is very different, their density being solar rather than terrestrial, and they probably possess no solid surface. When we come to contemplate our Earth, we must regard it not as an insignificant planet, but as a great and mighty world which for ages has been fulfilling its destiny, and will continue

to fulfil it until 'Heaven and Earth shall pass away.'

The Pleiades

The immemorial cluster of the Pleiades, familiar in legend and instructive in science, is perhaps the most pleasing and interesting aggregation of stars visible in the heavens. The 'sweet influences' believed to be shed down upon Earth by the vivid components of this group, and their close association with human destinies, have rendered them almost sacred among the different races of mankind. In every region of the globe, and in every clime—among civilised peoples and untutored savage tribes—the same benign influences were ascribed to the stars that enter into the formation of this beautiful cluster.

In Greek mythology they were known as the seven daughters of Atlas and Pleione. Different versions are given of their fate. By some writers it is recorded they died of grief in consequence of the death of their sisters the Hyades, or, on account of the fate of their father, who for high treason was condemned by Zeus (Jupiter) to support on his head and hands the vault of Heaven on the mountains of north-west Africa that bear his name. By others it is said they were the companions of Diana, and in order to escape from Orion, by whom they were pursued, the gods translated them to the sky. All writers affirm that after their death or translation, they were transformed into stars. Their names

are Alcyone, Atlas, Electra, Maia, Merope, Taygeta, and Celæno the invisible star. When looked at directly, six stars only are visible, but should the eye be turned sideways, seven or more can be seen.

The universality of the belief in the legend of the 'lost Pleiad' would seem to indicate that in the prehistoric past one of the stars in the cluster shone with a brilliancy that it has since lost. Homer and Attalus mention six stars as the number visible; Hipparchus and Aratus seven. Ovid writes:

> Quae septem dici, sex tamen esse solent.

That they 'were seven who now are six,' is a belief that was almost universally upheld by the nations inhabiting different regions of the globe.

In accounting for the legend of the 'lost Pleiad,' it has been suggested that some of the stars in the cluster may be slowly variable, i.e. their light may fluctuate so that a star of this type may gradually diminish in lustre until it becomes invisible—the existence of such stars being well known to astronomers. In this instance, the 'veiled face' of the seventh Atlantid may at the present time represent a star that in bygone ages was a conspicuous object.

The vivid scintillation of the Pleiades and their onward joyous dance have, from the earliest ages, riveted the attention of mankind. In the Book of Job there is the well-known beautiful allusion to the Pleiades:

> Canst thou bind the sweet influences of Pleiades,
> Or loose the bands of Orion?

All petitions presented to the ancient kings of Persia were graciously granted on the day of the midnight culmination of the Pleiades, which occurred on November 17. The Greeks, from an early period in their history, were deeply interested in the Pleiades, and regarded the heliacal rising of those stars as a favourable time for embarking on a voyage. A passage from Hesiod, construed into rhyme, reads:

> There is a time when forty days they lie,
> And forty nights, concealed from human eye;
> But in the course of the revolving year,
> When the swain sharps the scythe, again appear.

The Pleiades are invisible during the summer months, but early in September appear low down in the east; in November they arrive on the meridian, and form one of the most attractive objects in our winter skies.

With telescopic aid the number of stars in the cluster is largely augmented; Galileo counted thirty-six, and Hooke, with an object-glass barely three inches in diameter, enumerated seventy-eight stars. Large modern telescopes have disclosed the presence of several thousand stars in this region, but it is impossible to determine whether they are associated with the cluster or are merely part of the star-population of the heavens.

The Pleiades are exceedingly remote, their estimated light-period of 250 years indicating a distance of 1500 billion miles. Our Sun thus far removed would shrink to the dimensions of a tenth magnitude star and become invisible.

> There can be little doubt in fact, [writes Miss Agnes Clerke] that the solar brilliancy is surpassed by sixty to seventy of the Pleiades. And it must be, in some cases, enormously surpassed; by Alcyone 1000, by Electra 480, by Maia nearly 400 times. Sirius itself takes a subordinate rank when compared with the five most brilliant members of a group, the real magnificence of which we can thus in some degree apprehend.

This is the only star-cluster that has an ascertained common proper motion. Its constituents form a magnificent system in which the stars bear a mutual relationship to each other, and accomplish intricate internal revolutions, whilst they in systemic union drift together through the depths of space.

Within a comparatively recent period, a faint nebula has been discovered surrounding the four principal stars in the Pleiades. From its edges extend streamers, rays, and filaments, that wind among the outlying stars of the cluster. This intertwining of nebula and star reminds us of Tennyson's felicitous lines:

> Many a night I saw the Pleiads, rising thro' the mellow shade,
> Glitter like a swarm of fire-flies tangled in a silver braid.

Milton alludes to the Pleiades on two occasions. In describing the joyousness associated with the birth of the Universe, the poet mentions the bright surroundings that accompanied the Sun when setting out on his first journey. Preceding him—

> the grey
> Dawn, and the Pleiades, before him danced,
> Shedding sweet influence.—vii. 373–75.

The Ancients believed that the influence of the

stars, whether for good or for evil, was exercised, not in the night, but in the day, when their rays mingled with those of the Sun.

Milton, when describing the Sun's altered path among the constellations, mentions the seven 'Atlantic Sisters'—the seven daughters of Atlas—the Pleiades that are situated in Taurus, the second sign of the zodiac.

The Galaxy

The Galaxy or Milky Way is the great luminous zone that can be seen extending across the heavens from horizon to horizon. Its diffused nebulous appearance caused the Ancients much perplexity, and many quaint opinions were hazarded as to the nature of this celestial highway. But the mystery associated with its existence remained unsolved until Galileo directed his telescope to this lucent object, when, to his intense delight, he discovered that it consisted of myriads of stars—millions upon millions of orbs so distant as to be individually indistinguishable to the naked eye, and so closely aggregated that their blended light gave rise to the milky luminosity indicated by its name.

This stelliferous zone almost completely encircles the sphere, and divides it into two nearly equal parts. It is inclined at an angle of 63 degrees to the celestial equator, which it intersects in the constellations Monoceros and Aquila. In Cassiopeia it passes within 27 degrees of the north pole of the heavens, and in Crux is at a similar distance from the south

pole; its own poles are located in Coma Berenices and Cetus. The Milky Way varies from 5 degrees to 16 degrees in width, and is of irregular outline. In Centaurus it divides into two portions, one bright and well defined, the other indistinct and of interrupted continuity; these, after remaining apart for 120 degrees, reunite in Cygnus.

It is indeed [says a well-known astronomer] *only to the most* careless glance, or when viewed through an atmosphere of imperfect transparency, that the Milky Way seems a continuous zone. Let the naked eye rest thoughtfully on any part of it, and if circumstances be favourable it will stand out rather as an accumulation of patches, and streams of light of every conceivable variety of form and brightness; now side by side, now heaped on each other, again spanning across dark spaces, intertwining, and forming a most curious and complete network.

The stars in the Galaxy are very unevenly distributed. In some of its richest regions there have been enumerated within the space of a square degree as many stars as are visible to the naked eye on a clear night, but in other tracts they are much fewer in number. Adjacent to some of the most luminous portions of this zone, dark spaces and irregular channels can be perceived almost entirely devoid of stars. A remarkable instance of this kind occurs in the constellation of the Southern Cross, where, in a rich stellar region, there can be seen an oval-shaped dark vacuity 8° by 5° in extent, almost entirely denuded of stars. By early navigators it was known as the Coal-sack. When gazed upon, this gulf of 'Cimmerian darkness' conveys the impression of looking into a yawning

void of space far beyond the limits of the Milky Way. Similar dark spaces, though not of such magnitude, are visible in Ophiuchus, Scorpio, and Cygnus.

The Galaxy, when viewed with a powerful telescope, is found to consist of congeries of stars; vast

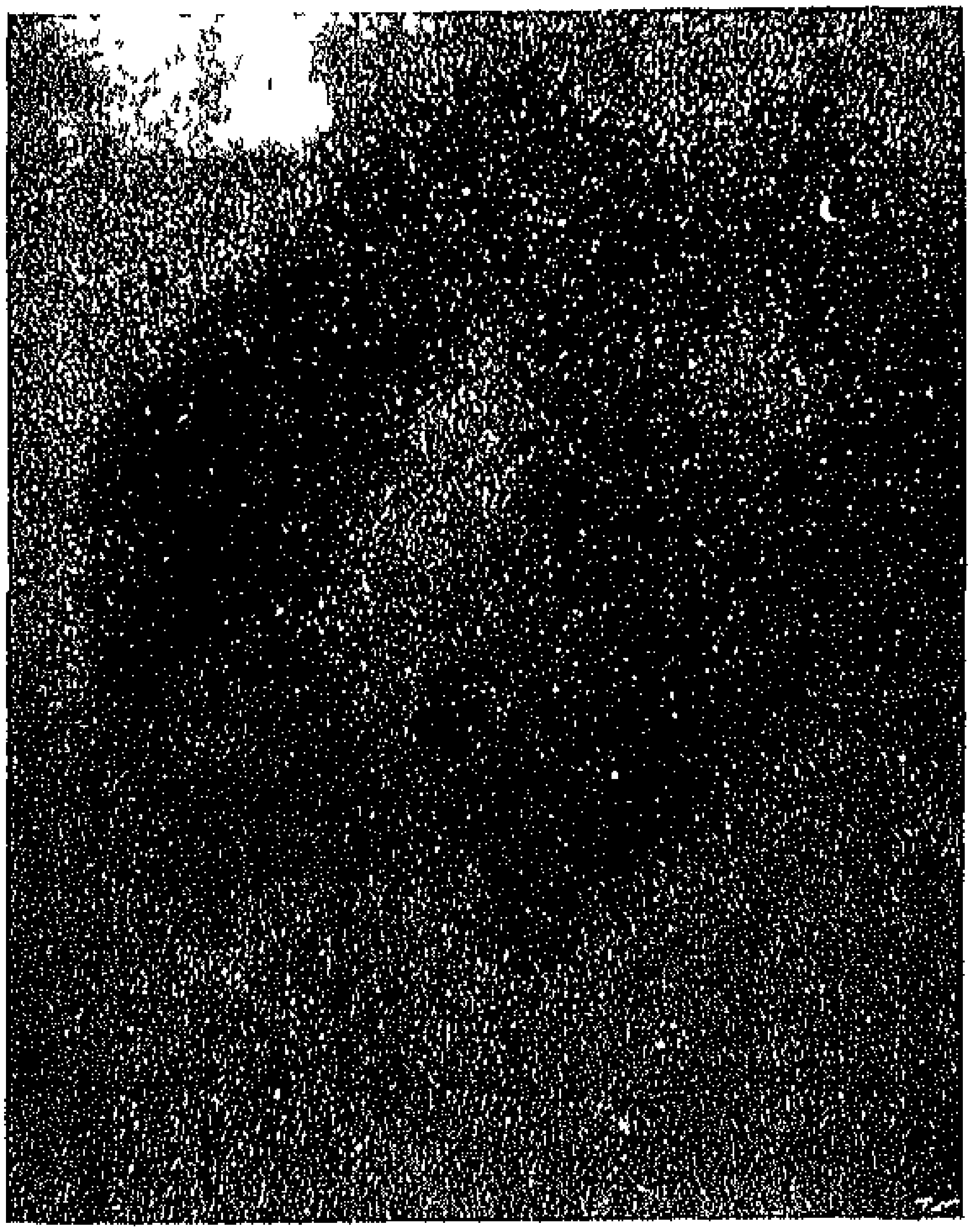


FIG. 7.—A Portion of the Milky Way.

stellar aggregations, great luminous tracts resolvable into clouds of stars of overpowering magnificence, superb clusters of various orders, and convoluted nebulous streams wandering 'with mazy error' among 'islands of light and lakes of darkness,' resolved by the telescope into banks of shining worlds. The concourses of stars that enter into the formation

of this wonderful zone exhibit in a marvellous degree the amazing profusion in which these orbs exist in certain regions of space; yet all of them perform their motions in harmonious unison, and in orderly array, and by their mutual attraction sustain the dynamical equilibrium of this stupendous galactic ring, the diameter of which, according to one authority, is traversed by light in not less than 13,000 years.

Sir William Herschel, who devoted a considerable period of his life to exploring with his great telescopes the depths and recesses of that portion of the Milky Way situated in the northern hemisphere, found its structure to be exceedingly intricate, and that within its limits were embraced an endless variety of systems, groups, clusters, branches, and streaming filaments of stars, all of which combined to form this luminous zone. In its richest tracts, which are in Perseus, Cygnus, and Aquila, Herschel perceived the stars present in marvellous profusion. During an observation, he computed that in the space of fifteen minutes 116,000 stars passed before his eye in the field of the telescope. On another occasion he estimated that 258,000 stars travelled in review before him in an interval of forty-one minutes; and in the constellation Cygnus, in a space five degrees in breadth, he surmised there were visible upwards of 331,000 stars.

Although Herschel was able to fathom the Galaxy in most of its tracts, yet there were regions which his great reflector was unable to penetrate. In Cephus there is a spot where he observed the stars 'become

gradually less till they escape the eye, so that appearances here favour the idea of a succeeding more distant clustering part.' He perceived another in Scorpio, 'where, through the hollows and deep recesses of its complicated structure, we behold what has all the appearance of a wide and indefinitely prolonged area strewed over with discontinuous masses, and clouds of stars which the telescope at last refuses to analyse.' The Great Cluster in Perseus, which is in the Milky Way, also baffled the penetrative capacity of Herschel's instruments. Professor Nichol, in describing the revealed glories of this inconspicuous object, says:

> In the Milky Way, thronged all over with splendours, there is one portion not unnoticed by the general observer, the spot in the sword-hand of Perseus. That spot shows no stars to the naked eye; the milky light which glorifies it comes from regions to which, unaided, we cannot pierce. But to a telescope of considerable power the space appears lighted up with unnumbered orbs; and these pass on through the depths of the infinite, until, even to *that penetrating* glass, they escape all scrutiny, withdrawing into regions unvisited by its power. Shall we adventure into these deeper retirements? Then, assume an instrument of higher efficiency, and *lo! the change is only repeated; those* scarce observed before appear as large orbs, and behind, a new series begins, shading gradually away, leading towards farther *mysteries! The illustrious Herschel penetrated on one occasion* into this spot, until he found himself among depths whose light could not have reached him in much less than four thousand *years; no marvel that he withdrew from the pursuit, conceiving* that such abysses must be endless.

With the most powerful telescopes of modern construction, the nebulosity of the more distant tracts of the Milky Way is incapable of definition,

although its stellar nature is strongly indicated; even the penetrating capacity of the great refractor of the Lick Observatory is unable to resolve the finer parts of the Galaxy into stars, the receding nebulosity being beyond the power of the instrument.

The stars of the Milky Way are so inconceivably remote that it is futile to surmise their distance. Their light-journey may embrace a period of many hundreds, or even several thousand years, so profound is the abyss of space that intervenes between us and those stars. Of their magnitude it is impossible to speak with any degree of certainty, but there are good reasons for concluding that the stars of the Galaxy equal, and may often surpass, our Sun in brilliance and luminosity. The 'swarms of the Milky Way' lie at a distance intermediate between the distances of stars of the tenth and fourteenth magnitudes; our Sun, thus far removed, would appear a much fainter object in the telescope; it would barely attain the fifteenth magnitude. We should therefore be justified in regarding the galactic stars as being by no means of subordinate importance, but that in lustre and light-giving power they may equal the Sun.

Those myriad suns are in ceaseless motion—in Nature a stationary body is unknown—and their distances apart are so regulated that in accomplishing their revolutions no undue disturbance of their mutual gravitational attraction occurs.

Milton refers but once to the Milky Way. The passage is, however, one worthy of the great starry

zone. The poet gives a singularly accurate description of this luminous track, which he glorifies as the way by which the Deity ascended to the Heaven of Heavens, after having completed His great work of creation:

> He through Heaven,
> That opened wide her blazing portals, led
> To God's eternal house direct the way—
> A broad and ample road, whose dust is gold,
> And pavement stars, as stars to thee appear
> Seen in the Galaxy, that Milky Way
> Which nightly as a circling zone thou seest
> Powdered with stars.—vii. 574–81.

Milton was aware of the stellar constitution of the Galaxy, which was one of Galileo's earliest discoveries with the telescope.

Comets

In the Middle Ages, the sudden appearance of a comet in the heavens was regarded with mingled feelings of apprehension and dismay as presaging the occurrence of disasters and direful events among the nations of the Earth. A great comet heralded the birth of Mithridates, a comet blazed forth in the heavens when Julius Cæsar died, and the apparition of a conspicuous comet in 1456, the year in which the Turks captured Constantinople and threatened to overrun Europe, was hailed by Christendom with superstitious dread.

The word 'comet' is derived from the Greek κομη, 'hair'; the hirsute appearance of these

objects having procured for them that name. A comet consists of a bright central part called the *nucleus*, which is surrounded by a mass of nebulous matter known as the *coma;* both combined form the *head,* from which extends a luminous elongation of the coma—Shakespeare's 'crystal tresses'—termed the *tail.* The nucleus is often granular in appearance, and, in great comets, shines as a star of the first magnitude. The coma is of extreme tenuity, and small stars have been observed shining through it without any appreciable diminution of their light. The train or tail is frequently very conspicuous, and presents considerable diversity in form and length. Sometimes it is straight, at other times curved, and occasionally it is bifurcated. Some comets have exhibited two or more tails. The comet of 1743 possessed six tails, which gave it a beautiful fan-shaped appearance. Sometimes the tail extends over 60 or 70 degrees of arc, indicating a length of from 100 to 150 million miles. The Earth on two occasions has passed through the tail of a comet without any perceptible effect having been observed.

The celebrated comet of 1680 afforded Newton an opportunity of making observations which led to his discovery that comets obey the law of gravitation in the same manner as do the planets, and that their orbits conform to three out of the four possible sections into which a cone can be divided. Comets, whose paths are elongated ellipses, may be regarded as belonging to the solar system, and are

periodical. Those that describe parabolic and hyperbolic orbits may be regarded as stray objects that, having paid us one visit, never return.

The quantity of matter, even in large comets, is known to be exceedingly small. It is generally admitted that the nucleus consists of an aggregation, more or less dense, of meteoric fragments. These, when exposed to the Sun's heat, coruscate and throw off luminous particles that are swept by some repulsive force into space, and become conspicuous as the tail. This appendage is always directed away from the Sun.

The seventeenth century was rich in great comets; Halley's was seen on two occasions—first in 1607 and again in 1682. The great comet of 1680 will always be memorable as having afforded Newton an opportunity of calculating its orbit on gravitational principles. In 1618 several comets appeared in the heavens—one in particular had a remarkable appearance. It was observed in November of that year by Kepler, by Gassendi, and by our countryman Harriot, who describes it as one of the finest comets ever seen, having been visible in full daylight. Its head consisted of several nuclei, which later on appeared as a cluster of small stars. Its tail was computed to extend a length of 100 million miles. At the time when this comet appeared, Milton was ten years old, so that the apparition of this imposing object must have made a deep and lasting impression upon his mind. The only other comet of note that appeared in Milton's life-

time was one which was seen in 1652. Hevelius describes it as having been as large as the Moon when half full, and that it shone with a pale livid light. Although Milton, doubtless, may have heard much about this comet, it could not have interested him greatly, for in 1652 he was totally blind. Milton was then in his forty-fourth year.

Milton on two occasions introduces a comet in the 'Paradise Lost.' When describing the hostile meeting between Satan and Death before the gates of Hell, the poet says:

> On the other side,
> Incensed with indignation, Satan stood
> Unterrified, and like a comet burned,
> That fires the length of Ophuichus huge
> In the arctic sky, and from his horrid hair
> Shakes pestilence and war.—ii. 706–11.

This passage is eminently descriptive of a great comet, and of the dread and dismay with which those unwelcome visitors were regarded by mankind. The comparison of the enraged Prince of Hell, amid his lurid surroundings, to a great fiery comet, is singularly appropriate, and worthy of the mighty combatant.

The constellation Ophiuchus or Serpentarius (the serpent-bearer) is represented by the figure of a man holding in both hands a large snake. It occupies a rather barren region of the heavens to the south-east of Hercules, and although unattractive to the naked eye, yet contains some interesting telescopic objects. Its magnitude is considerable, and in length it extends about forty degrees. In describing Ophiuchus as 'in

the arctic sky,' Milton does not assign the constellation its true position, for it lies nowhere near the polar region of the heavens, but is situated in the south-eastern sky, where it is intersected by the equator. The poet, who was well acquainted with the relative positions of the principal constellations, appears to have been unfamiliar with that of Ophiuchus. There are not many astronomers who can delineate this rather obscure constellation, situated as it is in a region devoid of any celestial objects that would attract the attention of an observer.

It would be interesting to know why Milton selected Ophiuchus as the constellation in which he located his comet. The expression 'Ophiuchus huge' is striking, and has a ponderous rhythm that must have caught Milton's poetical ear. But had he some knowledge of the history of comets, which perhaps he had, he would have learned that two great comets, one in A.D. 178 the other in 891, travelled through Ophiuchus. On the other hand, comets were numerous in the seventeenth century, and it is possible the poet might have seen one in the region of the sky in which Ophiuchus is situated.

In the final act in the great drama unfolded in his sublime epic, viz. the removal of our first parents from Paradise, Milton compares the sword of God to a flaming comet. Preceding the Cherubim, who in bright array descended to take possession of the Garden—

> High in front advanced,
> The brandished sword of God before them blazed,
> Fierce as a comet; which with torrid heat,

And vapour as the Lybian air adust,
Began to parch that temperate clime; whereat
In either hand the hastening angel caught
Our lingering parents, and to the eastern gate
Led them direct, and down the cliff as fast
To the subjected plain; then disappeared.
They, looking back, all the eastern side beheld
Of Paradise, so late their happy seat,
Waved over by that flaming brand; the gate
With dreadful faces thronged and fiery arms.

XII. 632–44.

Comets may be regarded as entirely innocuous; neither danger nor harm need be apprehended from their visits: they come to please and instruct, not to injure and destroy.

Meteors and Falling Stars

Unlike comets, meteors and falling stars are evanescent bodies that indicate their presence by an intensely brilliant flare, or by a momentary streak of light athwart the sky. A few falling stars may be seen on any clear night, but the sudden appearance of a large meteor is of rare occurrence. Occasionally a meteor appears as a fire-ball, which, after a momentary flight, drops to the Earth or plunges into the ocean. Fire-balls sometimes explode with a loud detonation.

Meteors and falling stars are of cosmical origin, and vary from a grain to a few tons in weight. They occupy interplanetary space, and travel with a speed *of from thirty to forty miles a second. This velocity,* when they reach the higher regions of the Earth's atmosphere, proves fatal to most of them, for the heat evolved by friction with the air becomes so

intense that they are rendered incandescent, and are finally resolved into a streak of glowing vapour, which becomes visible to us as a falling, or shooting star. Fragments of large meteors reach the Earth, and have been picked up from time to time, or found deeply embedded in the ground.

Shooting Stars usually form vast aggregations, each individual member of which pursues its own path, whilst collectively they travel round the Sun in highly elongated ellipses inclined at all angles to the plane of the ecliptic. They glide along in absolute silence, and no sound is heard at the moment of their dissolution. Most of them are probably no larger than a pea or small pebble, but as the Earth encounters millions of them daily, our globe would be scarcely habitable were it not for the protection afforded by her atmosphere, in which they are consumed.

The region of the sky from which the meteors appear to diverge is called the 'radiant point.' If it should be overhead, and the arrows of light are very numerous, they will resemble a parachute of fire; if below the horizon, the meteors will ascend into the sky like rockets. As the radiant point is fixed, the meteors are usually named after the constellation in which it is situated. The August meteors, which recur annually about the 10th of the month, are called Perseids, because they radiate from a point in the constellation Perseus. Those in Taurus, Taurids; in Lyra, Lyraids, and in Andromeda, Andromedes.

The falling stars that have attracted most attention are the November meteors; they are called Leonids, because they radiate from a point in the constellation Leo. A few may be seen about the 13th and 14th of the month in each year, but three times in a century, or about once in thirty-three years, a grand meteoric display occurs, when the stars appear to rain down upon the Earth. The earliest allusion to this meteoric shower is by Theophanes, who states that in the year A.D. 472 the sky at Constantinople appeared to be on fire with falling stars. Another remarkable visitation is recorded as having occurred in 902, and from that date up to 1833 twelve conspicuous displays are mentioned as having taken place. In the latter year the grandest spectacle of this kind ever witnessed visited the North American Continent. The meteoric shower commenced at midnight and lasted for four or five hours. During its continuance the stars fell almost as thickly, and as silently, as snow-flakes, and caused great consternation, many of those who witnessed the phenomenon believing that the end of the world was at hand.

The regular recurrence of these meteoric displays has been satisfactorily explained on the assumption that the Leonids accomplish a revolution of their orbit round the Sun in $33\frac{1}{4}$ years. In pursuing her annual journey, the Earth, once in each year, intersects the path of the meteors and captures a few of them, but when she encounters the main swarm, which happens once in thirty-three years, millions of these

small objects are attracted to her surface, and in their downward flight become visible as falling stars. In November 1866 the shower returned, but in 1899, much to the disappointment of many eager watchers, the meteors failed to put in an appearance; consequently there were no celestial fireworks. Owing to the perturbative influence of Jupiter and of Saturn, the swarm was caused to swerve slightly from its usual path, and as a consequence millions of meteors escaped destruction by not coming within the influence of the Earth's attraction. The occurrence of these meteoric displays can now no longer be relied upon, and they may never recur again.

Milton refers to these celestial objects as meteors, shooting stars, and falling stars. The poet, in describing Uriel's rapid flight from the Sun to Paradise, likens his speed to the velocity of a shooting star:

> Thither came Uriel, gliding through the even
> On a sunbeam, swift as a shooting star
> In autumn thwarts the night, when vapours fired
> Impress the air, and shows the mariner
> From what point of his compass to beware
> Impetuous winds.—iv. 555-60.

The notion prevalent in Milton's time concerning the nature of meteors and falling stars was that they were mere *ignes fatui*—inflammable vapours that became accidentally ignited in the atmosphere. They were also regarded as the precursors of stormy weather. A passage in Virgil testifies to this:

> Oft shalt thou see ere brooding storms arise,
> Star after star glide headlong down the skies.

In describing the fall of Mulciber from Heaven, Milton says:

> from morn
> To noon he fell, from noon to dewy eve,
> A summer's day; and with the setting sun
> Dropt from the zenith, like a falling star,
> On Lemnos, the Ægaean isle.—i. 742–46.

Azazel, a 'Cherub tall,' claimed the distinction of bearing the mighty standard of the Infernal Powers—

> Who forthwith from the glittering staff unfurled
> The imperial ensign, which, full high advanced,
> Shone like a meteor streaming to the wind.—i. 535–37.

The simile is a striking one, and eminently adapted to the situation.

In '*Comus*,' *the Attendant Spirit says*:

> Swift as the sparkle of a glancing star
> I shoot from Heaven.—C. 80–1.

Milton's references to these meteoric bodies are all very beautiful, and their pleasing effect is much enhanced by the harmonious rhythm of the verse, in which the poet felicitously adjusts the sound to the sense.

CHAPTER VIII

MILTON'S DESCRIPTIVE ASTRONOMY

The prime charm of Milton's poetic genius is at no time more apparent than when he gives utterance to thoughts expressive for his admiration for the celestial orbs, and of the varied phenomena that accompany their motions. His vivid perception of the beautiful, together with the melodious flow of his harmonious verse, have enabled him to favour us with those charming descriptions of the planetary and stellar orbs that enhance so much the attractiveness of several of his poems.

Urania—the Heavenly Muse—whose aid Milton invoked at the commencement of his poem, and under whose divine guidance he soared up to the Heaven of Heavens and breathed empyreal air, he now implores to lead him down to his native element lest he might meet with the fate that befel Bellerophon.

> Descend from Heaven, Urania, by that name
> If rightly thou art called, whose voice divine
> Following, above the Olympian hill I soar,
> Above the flight of Pegasean wing!
> The meaning, not the name, I call; for thou
> Nor of the Muses nine, nor on the top

Of old Olympus dwell'st; but Heavenly-born,
Before the hills appeared or fountain flowed,
Thou with eternal Wisdom didst converse,
Wisdom thy sister, and with her didst play
In presence of the Almighty Father, pleased
With thy celestial song. Up led by thee,
Into the Heaven of Heavens I have presumed,
An earthly guest, and drawn empyreal air,
Thy tempering: with like safety guided down,
Return me to my native element;
Lest, from this flying steed unreined (as once
Bellerophon, though from a lower clime)
Dismounted, on the Aleian field I fall,
Erroneous there to wander, and forlorn.
Half yet remains unsung, but narrower bound
Within the visible diurnal sphere.
Standing on Earth, not rapt above the pole,
More safe I sing with mortal voice, unchanged
To hoarse or mute, though fallen on evil days,
On evil days though fallen, and evil tongues;
In darkness, and with dangers compassed round,
And solitude; yet not alone, while thou
Visit'st my slumbers nightly, or when morn
Purples the east. Still govern thou my song,
Urania, and fit audience find though few.—vii. 1–32.

The loftiness of Milton's imagination, and the majesty of his diction, are eminently displayed in the description given of the Creation by the archangel Uriel:

I saw when at His word the formless mass,
This World's material mould, came to a heap;
Confusion heard His voice, and wild Uproar
Stood ruled, stood vast infinitude confined;
Till at His second bidding darkness fled,
Light shone, and order from disorder sprung.
Swift to their several quarters hasted then
The cumbrous elements, Earth, Flood, Air, Fire;
And this ethereal quintessence of Heaven

Flew upward, spirited with various forms
That rolled orbicular, and turned to stars
Numberless, as thou see'st, and how they move;
Each had his place appointed, each his course;
The rest in circuit walls this Universe.—iii. 708–21.

The same sublimity of utterance is sustained by the poet when describing the progress of the Messiah on His great expedition—the bringing into being of a new Universe—the Heavens and the Earth—in the creation of which He exhibits His almighty power:

Meanwhile the Son
On His great expedition now appeared,
Girt with omnipotence, with radiance crowned
Of majesty divine, sapience and love
Immense; and all His Father in Him shone.
About His chariot numberless were poured
Cherub and Seraph, Potentates and Thrones,
And Virtues, winged Spirits, and chariots winged
From the armoury of God, where stand of old
Myriads, between two brazen mountains lodged
Against a solemn day, harnessed at hand.
Celestial equipage; and now came forth
Spontaneous, for within them Spirit lived,
Attendant on their Lord. Heaven opened wide
Her everduring gates, harmonious sound
On golden hinges moving, to let forth
The King of Glory, in His powerful word
And Spirit coming to create new worlds.
On Heavenly ground they stood, and from the shore
They viewed the vast immeasurable Abyss,
Outrageous as a sea, dark, wasteful, wild,
Up from the bottom turned by furious winds
And surging waves, as mountains to assault
Heaven's highth, and with the centre mix the pole.
'Silence, ye troubled waves, and thou Deep, peace!'
Said then the omnific Word: 'your discord end!'
Nor stayed; but on the wings of Cherubim
Uplifted, in paternal glory rode

Far into Chaos, and the World unborn;
For Chaos heard His voice. Him all His train
Followed in bright procession, to behold
Creation, and the wonders of His might.
Then stayed the fervid wheels, and in His hand
He took the golden compasses, prepared
In God's eternal store, to circumscribe
This Universe, and all created things.
One foot He centred, and the other turned
Round through the vast profundity obscure;
And said, 'Thus far extend, thus far thy bounds;
This be thy just circumference, O World!'
Thus God the Heaven created, thus the Earth,
Matter unformed and void. Darkness profound
Covered the abyss; but on the watery calm
His brooding wings the Spirit of God outspread,
And vital virtue infused, and vital warmth,
Throughout the fluid mass; but downward purged
The black, tartareous, cold infernal dregs,
Adverse to life; then founded, then conglobed
Like things to like, the rest to several place
Disparted, and between spun out the air,
And Earth, self-balanced, on her centre hung.—
vii. 192–242.

Milton, in his description of the Creation, upholds with lofty eloquence his sublime conception of this latest display of Divine power, when God, by specific acts in certain stated periods of time, called into existence the visible Universe and all that it contains. The poet invests with becoming majesty all the acts of the Creator who, when He finished His great work, saw that 'all was entirely good.'

The varied phenomena that occur as a consequence of the motions of the heavenly bodies, and the diurnal rotation of the Earth on her axis, are accompanied by those agreeable changes in the aspect

of Nature with which all are familiar. The rosy *footsteps of morn, the solar splendour of noonday,* the fading hues of even, and night with her jewelled courts and streams of molten stars, have been universally sung by all poets with unfailing delight. In his portrayal of these pleasing vicissitudes in Nature, Milton is unsurpassed. He expresses himself thus:

> Sometime walking, not unseen,
> By hedge-row elms, on hillocks green,
> Right against the eastern gate,
> Where the great Sun begins his state,
> Robed in flames, and amber light,
> The clouds in thousand liveries dight.—L'A. 59-62.

Or:

> To behold the wandering Moon,
> Riding near her highest noon,
> Like one that had been led astray
> Through the heaven's wide pathless way;
> And oft, as if her head she bowed,
> Stooping through a fleecy cloud.—Il P. 67-72.

Surely no poet has given us a lovelier description of Evening, or has enhanced *its beauty* more, by allusion to the celestial orbs, than Milton, when he describes the first evening in Paradise:

> *Now came still Evening on, and Twilight gray*
> Had in her sober livery all things clad;
> Silence accompanied; for beast and bird,
> They to their grassy couch, these to their nests,
> Were slunk, all but the wakeful nightingale;
> She all night long her amorous descant sung;
> Silence was pleased. Now glowed the firmament
> With living sapphires; Hesperus, that led

The starry host, rode brightest, till the Moon,
Rising in clouded majesty, at length
Apparent queen, unveiled her peerless light,
And o'er the dark her silver mantle threw.
iv. 598-609.

In the following citation, Milton felicitously indicates the period of the day by referring to the positions of certain orbs, and describing their course in the heavens:

The star that bids the shepherd fold
Now the top of heaven doth hold;
And the gilded car of Day,
His glowing axle doth allay
In the steep Atlantic stream;
And the slope Sun his upward beam
Shoots against the dusky pole,
Pacing toward the other goal
Of his chamber in the east.—C. 93-101.

Perhaps no more movingly beautiful passage, or one that breathes such fervid poetic sentiment, can be found in any of Milton's poems than the following:

O thievish Night,
Why shouldst thou, but for some felonious end,
In thy dark lantern thus close up the stars
That Nature hung in Heaven, and filled their lamps
With everlasting oil, to give due light
To the misled and lonely traveller?—C. 195-200.

The Morning Hymn of Praise which Adam and Eve offer up in concert to their Maker, contains their loftiest thoughts and most reverent sentiments expressed in melodiously flowing verse. In their solemn invocations, they call upon the orbs of the firmament to join in praising and extolling the Creator, and in their devout adoration, address by

name those that are most conspicuous. Hesperus, 'fairest of stars,' is asked to praise Him in her sphere. The Sun, great image of his Maker, is told to acknowledge Him his greater, and to sound His praise in his eternal course. The Moon, the planets, and the fixed stars are called upon to resound the praise of the Creator, whose glory is displayed in the Heavens:

> Fairest of Stars, last in the train of night,
> If better thou belong not to the dawn,
> Sure pledge of day, that crowns't the smiling Morn
> With thy bright circlet, praise Him in thy sphere
> While day arises, that sweet hour of prime.
> Thou Sun, of this great world both eye and soul,
> Acknowledge Him thy greater; sound His praise
> In thy eternal course, both when thou climb'st,
> And when high noon hast gained, and when thou fall'st.
> Moon, that now meet'st the orient Sun, now fliest
> With the fixèd stars, fixed in their orb that flies;
> And ye five[1] other wandering Fires, that move
> In mystic dance, not without song, resound
> His praise who out of darkness called up light.
>
> v. 170-79.

The following passage illustrates how, when describing phenomena of almost everyday occurrence, a great poet can, by a touch of his genius, impart to others the sentiments which he breathes, thus awakening in the mind a higher conception of the beautiful. After having listened to the archangel

[1] Several of Milton's commentators have suggested that the poet, after having addressed Venus as the Morning Star, is in error by invoking five other planets—the number should be four, viz. Mercury, Mars, Jupiter, and Saturn. But it must be remembered that it is Adam who expresses himself, and, naturally enough, he is unaware that the Morning and Evening stars are one and the same planet. Consequently Venus is again included as the Evening Star, and according to this interpretation of the passage the number 'five' is correct.

Raphael's long narration of what happened in Heaven prior to the creation of the Universe, Adam, who is deeply interested, requests him to relate how the Earth and surrounding heavens were called into existence, and in alluding to the unexpired portion of the day, he says to his celestial visitor:

And the great Light of Day yet wants to run
Much of his race, though steep. Suspense in heaven
Held by thy voice, thy potent voice, he hears,
And longer will delay, to hear thee tell
His generation, and the rising birth
Of Nature from the unapparent Deep;
Or if the Star of Evening and the Moon
Haste to thy audience, Night with her will bring
Silence, and Sleep listening to thee will watch;
Or we can bid his absence till thy song
End, and dismiss thee ere the morning shine.

vii. 98–108.

The poet, in order to escape from the heat and glare of the blazing Sun, desires to be brought where umbrageous shade excludes the solar rays:

And when the Sun begins to fling
His flaring beams, me Goddess bring
To archèd walks of twilight groves,
And shadows brown that Sylvan loves,
Of pine, or monumental oak,
Where the rude axe with heavèd stroke
Was never heard the nymphs to daunt
Or fright them from their hallowed haunt.
There, in close covert by some brook,
Where no profaner eye may look,
Hide me from Day's garish eye,
While the bee with honeyed thigh,
That at her flowery work doth sing,
And the waters murmuring,
With such consort as they keep,
Entice the dewy-feathered Sleep.

And let some strange mysterious dream
Wave at his wings, in airy stream
Of lively portraiture displayed,
Softly on my eyelids laid;
And, as I wake, sweet music breathe
Above, about, or underneath,
Sent by some Spirit to mortals good,
Or the unseen Genius of the wood.—Il P. 131–54.

The 'Ode on the Nativity,' which was composed by Milton when twenty-one years of age, contains numerous happy allusions to the celestial orbs, all of which enhance the solemn richness of the melody breathed in the poem:

Say, Heavenly Muse, shall not thy sacred vein
Afford a present to the Infant God?
Hast thou no verse, no hymn, or solemn strain,
To welcome him to this his new abode,
Now while the heaven, by the Sun's team untrod,
Hath took no print of the approaching light,
And all the spangled host keep watch in squadrons bright?

On the night of the birth of Christ:

The stars with deep amaze,
Stand fixed in steadfast gaze,
Bending one way their precious influence,
And will not take their flight,
For all the morning light,
Or Lucifer that often warned them thence;
But in their glimmering orbs did glow,
Until their Lord himself bespake, and bid them go.

And though the shady gloom
Had given day her room,
The Sun himself withheld his wonted speed,
And hid his head for shame,
As his inferior flame
The new enlightened world no more should need:
He saw a greater Sun appear
Than his bright throne or burning axle-tree could bear.

In the concluding stanza of the poem, a star is mentioned as being in waiting upon the infant Saviour when asleep :

> But see! the Virgin blest
> Hath laid her Babe to rest,
> Time is our tedious song should here have ending;
> Heaven's youngest teemèd star
> Hath fixed her polished car,
> Her sleeping Lord with handmaid lamp attending;
> And all about the courtly stable
> Bright-harnessed Angels sit in order serviceable.

The Saviour, in meditating upon the fulfilment of His mission, repeats the words uttered by His mother respecting Himself :

> 'A star, not seen before, in heaven appearing,
> Guided the wise men thither from the East,
> To honour thee with incense, myrrh, and gold;
> By whose bright course led on, they found the place,
> Affirming it thy star, new-graven in heaven.'
>
> P. R. i. 249-53.

In his poem 'On the Death of a Fair Infant,' Milton, musing over the fate of the babe, inquires :

> Wert thou some star, which from the ruined roof
> Of shaked Olympus by mischance didst fall;
> Which careful Jove in Nature's true behoof
> Took up, and in fit place did re-instal?
> Or did of late Earth's sons besiege the wall
> Of sheeny Heaven, and thou some goddess fled
> Amongst us here below to hide thy nectared head?
>
> 43-9.

In the avowal of her conjugal love, Eve, with charming expression, associates the orbs of the firmament with the delightful aspects in Nature that meet her admiring gaze :

Sweet is the breath of Morn, her rising sweet,
With charm of earliest birds; pleasant the Sun,
When first on this delightful land he spreads
His orient beams, on herb, tree, fruit, and flower,
Glistering with dew: fragrant the fertile Earth
After soft showers; and sweet the coming on
Of grateful Evening mild; then silent Night,
With this her solemn bird, and this fair Moon,
And these the gems of Heaven, her starry train:
But neither breath of Morn, when she ascends
With charm of earliest birds; nor rising Sun
On this delightful land; nor herb, fruit, flower;
Glistering with dew; nor fragrance after showers;
Nor grateful Evening mild; nor silent Night,
With this her solemn bird; nor walk by Moon,
Or glittering star-light, without thee is sweet.
But wherefore all night long shine these? for whom
This glorious sight, when sleep hath shut all eyes?

iv. 641-58.

One of the charms of Milton's verse is the devoutly poetical sentiment that pervades it. His thoughts, though serious, are not austere, and his reverence is most apparent in his loftiest musings. This is conspicuous in Adam's reply to the inquiry addressed to him by Eve:

'Daughter of God and Man, accomplished Eve,
These have their course to finish round the Earth
By morrow evening, and from land to land
In order, though to nations yet unborn,
Ministering light prepared, they set and rise;
Lest total Darkness should by night regain
Her old possession, and extinguish life
In Nature and all things; which these soft fires
Not only enlighten, but with kindly heat
Of various influence foment and warm,
Temper or nourish, or in part shed down
Their stellar virtue on all kinds that grow
On Earth, made hereby apter to receive

Perfection from the Sun's more potent ray.
These, *then, though unbeheld in deep of night,*
Shine not in vain; nor think, though men were none,
That Heaven would want spectators, God want praise:
Millions of spiritual creatures walk the Earth
Unseen, both when we wake, and when we sleep:
All these with ceaseless praise his works behold
Both day and night. How often, from the steep
Of echoing hill or thicket, have we heard
Celestial voices to the midnight air,
Sole, or responsive each to other's note,
Singing their Great Creator! Oft in bands
While they keep watch, or nightly rounding walk,
With heavenly touch of instrumental sounds
In full harmonic number joined, their songs
Divide the night, and lift our thoughts to Heaven.'
iv. 660–88.

The concluding stanza in 'Lycidas' contains a pleasing allusion to sunset and the expiring day:

Thus sang the uncouth swain to the oaks and rills,
While the still Morn went out with sandals gray;
He touched the tender stops of various quills,
With eager thought warbling his Doric lay:
And now the Sun had stretched out all the hills,
And *now was dropt into the western bay,*
At last he rose, and twitched his mantle blue;
To-morrow to fresh woods, and pastures new.—L. 186–93.

Our first parents, before retiring to rest, do not forget in their devotions to refer to the celestial orbs as indicating the power and goodness of the Creator:

Thus at their shady lodge arrived, both stood,
Both turned, and under open sky adored
The God that made both Sky, Air, Earth, and Heaven,
Which they beheld, the Moon's resplendent globe,
And starry pole.—iv. 720–24.

After having described in 'Il Penseroso' the serene and contemplative pleasures associated with Melancholy, Milton concludes the poem with the following refrain:

> And may at last my weary age
> Find out some peaceful hermitage,
> The hairy gown and mossy cell,
> Where I may sit and rightly spell
> Of every star that heaven doth shew,
> And every herb that sips the dew;
> Till old experience do attain
> To something like prophetic strain.—167–74.

The numerous extracts and quotations contained in this volume testify to the frequency and delight with which Milton's thoughts turn to the phenomena of the heavens. The poet's love of astronomy is nowhere more apparent than in the 'Paradise Lost,' in which we find page after page devoted to the discussion of astronomical theories, whilst many of its choicest passages are descriptive of the orbs of the firmament, and of the glories of the nocturnal sky.

The chief characteristic of Milton's poetry is its sublimity. The loftiness of his muse is admitted by all readers who have perused his works. No poet soared with greater ease, or sustained himself so long in the sublime, as Milton, who in the heavenward flights of his genius depicted the glories of the sidereal heavens, and unveiled the eternal splendours of the Empyrean.

In his incursions into the realms of literature, science, and philosophy, in which his imagination

wove its brightest visions, no more enticing subject allured his mind, or afforded his poetic fancy such facilities for its loftiest flights, than the sublimest of sciences—astronomy. Whether we most admire the accuracy and comprehensiveness of his astronomical knowledge, or his charming descriptions of the celestial orbs and the pleasing phenomena that accompany them, it is apparent that in this domain of science Milton, as a poet, stands alone and unrivalled.

In his portrayal of the celestial orbs, Milton, with marked discernment, depicts the individual splendours peculiar to each. The Sun, above all, is accorded that precedence which is his due; nor does the poet ever fail to surround him with the 'surpassing glory' that distinguishes him from all other occupants of the sky. The Moon—his consort—peerless in the subdued effulgence of her borrowed light, the beautiful morning and evening star Hesperus, the Galaxy, overpowering in the magnificence of its clouds and streams of stars, and the Sidereal Heavens with their untold glories, have each their distinctive features and charms mirrored in the pages of this remarkable poem. The wealth of astronomical allusion and detail contained in the 'Paradise Lost' bears testimony to the irresistible charm exercised over the poet's mind by the orbs which tenant the depths of space. With Milton they were an unfailing source of lofty contemplation and of meditative delight. The following citation testifies to the poet's

admiration of all that he beheld as indicating the power and wisdom of the Creator:

> For wonderful indeed are all his works,
> *Pleasant to know, and worthiest to be all*
> Had in remembrance always with delight!
> But what created mind can comprehend
> Their number, or the wisdom infinite
> That brought them forth, but hid their causes deep.
> iii 703–8.

It is needless to remark how pleasing and instructive it is to know the astronomy of Milton's 'Paradise Lost'; nor can it be denied with what seductive charm one is enticed to linger over the harmonious utterances associated with the sublimest of sciences felicitously expressed in the melodious language of England's greatest epic poet.

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THE END

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